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HYDROBIOLOGIA publishes original articles in the field of Hydrobiology, Hydrography and Protistology. It will include investigations in the field of marine and freshwater Zoo- and Phytobiology, embracing also research on the Systematics and Taxonomy of the groups covered. Preliminary notices, polemics, and articles published elsewhere will not be accepted. The journal, however, contains reviews of recent books and papers.

Four numbers of the journal are published every year. Each number averages about 100 pages. Contributions must be clearly and concisely composed. They must be submitted in grammatically correct English, French, German, Italian or Spanish. Long historical introductions are not accepted. Protocols should be limited. Names of animals and plants must be given according to the laws of binominal nomenclature adopted at the recent International Congresses of Zoology and of Botany, including the author's name; it is desirable that the latter should be given in full. Measures and weights should be given in the decimal system. Every paper has to be accompanied by a short summary, and by a second one, written in an alternative language.

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An undescribed species of Dunaliella from the Cambridge collection of algae

by

R. W. Butcher

Fisheries Laborators Burnham-on-Crouch, England

When studying the taxonomy of the halophytic forms of *Dunaliella*, I was kindly given, by Dr. E. George, cultures from the Cambridge Type collection of this genus. One of these (ref. no. 19/4) originated from Pascher in Prague (ref. no. 281), but the details of the locality are missing. Since this species has been used by Eddy (1956) in his investigations on the suitability of certain algae for mass culture and was for the purpose of his work assigned the provisional name of *Dunaliella bioculata*, a description of this organism is both desirable and necessary.

Dunaliella bioculata sp. n.

Cellula 8—10(12) × 4—5(6)μ cylindrica, seu oblonga, seu ovata, antica apice acuto, postica rotundata, chromatophoro campaniformi granulato $\frac{3}{4}$ cellulae implente margine anteriore lobato; pyrenoide basali vagina irregulariter lobata cincta stigmatibus saepins duobus densis elongatis rubris, aliquando singulis; granulis amyli paucis antice praedita.

Cells uncompressed, 8—10(12) × 4—5(6)μ, assuming varied shapes from oblong cylindrical to broadly ovoid or ellipsoid, anterior apex tapering gradually into an acute point, posterior rounded; periplast thin elastic; chromatophore campanulate, green, always granular and occupying all except $\frac{1}{4}$ of the cell at the anterior; edge, irregularly lobed; pyrenoid in the posterior part of the cell, about 3μ diam., surrounded by a continuous but rather irregular starch sheath; stigma in the anterior part of the cell, elongate, dense, red, two or rarely single or a greater number; flagella 2, $1\frac{1}{2}$ to twice as long as cell apparently homodynamic and simple; nucleus small, central. Cells also contain 1—40 medium starch grains or plastids,

in the anterior of the cell, but no small refractive globules are present. Haematochrome development not observed.

Type culture in the Cambridge collection; originally sent by A. PASCHER of Prague; collected by CZURA but locality unknown.

The distinguishing feature of the species is its one or two elongated stigmas and the almost invariably pointed anterior. It is smaller than *D. salina* TEOD. and has a pyrenoid of different structure from that of *D. parva* LERCHE which has a ring of numerous starch grains around the pyrenoid.

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EDDY, O. B. P. - 1956 - *J. Exp. Bot.*, 7, *327*.

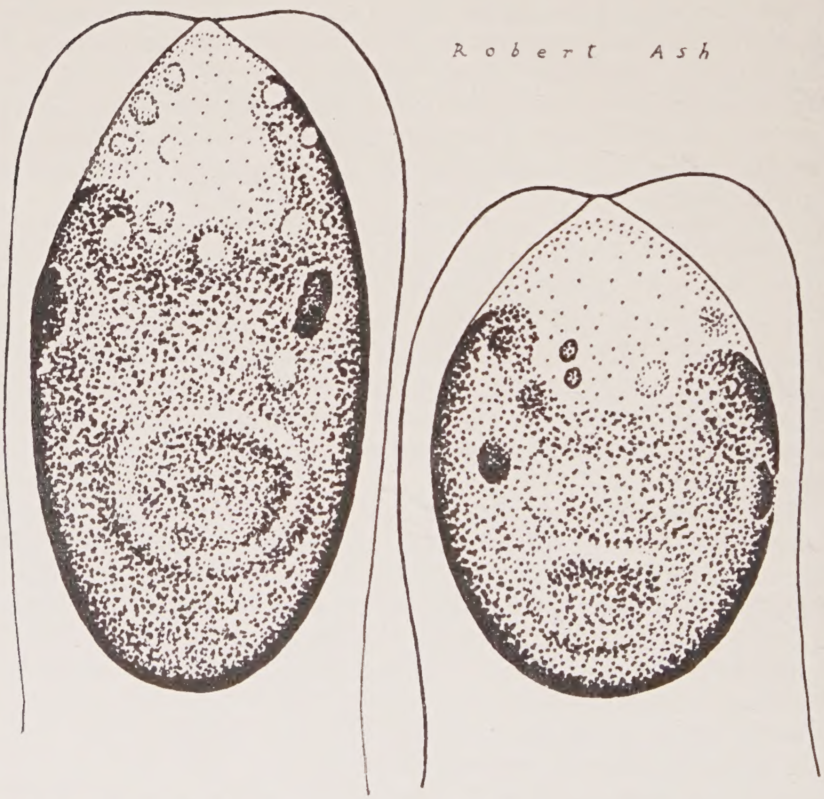

Fig. 1 and 2. *Dunaliella bioculata* two cells of somewhat different shape x 500.

Quelques Desmidiées dites Arctiques Alpines des marais du sud-ouest d'Uvira (Congo Belge)

par

PAUL VAN OYE (Gand)

En étudiant les Rhizopodes du matériel que M. J. J. SYMOENS a eu l'amabilité de m'envoyer des marais de la haute Ngovi près de Masaruzi à environ 16 km d'Uvira, (*Hydrobiologia* X, 85—137), j'ai rencontré quelques Desmidiées qui ont attiré mon attention.

Comme j'ai eu l'occasion de le faire remarquer en 1943 (Mission Lebrun), plusieures espèces qui étaient considérées comme alpines ou à tendance arctique-alpine se rencontrent au Congo. Le matériel examiné en 1943 provenait en grande partie d'altitudes de 2.000 m et plus.

Nous savons que les opinions concernant les espèces de Desmidiées arctiques alpines ou subarctiques ont beaucoup changé depuis que STEINECKE a attiré l'attention sur celles-ci.

Comme les auteurs ont surtout examiné du matériel des régions du nord de l'Europe, de l'Asie ou de l'Amérique, leur nomenclature s'en ressent. Il est certain que nous ne pouvons plus maintenir leur façon de voir, maintenant que nous savons que ces espèces se rencontrent en quantité dans les régions équatoriales. Néanmoins il est tout aussi vrai que les faits sur lesquels se basaient les auteurs anciens n'en restent pas moins exacts. Ce n'est pas l'acquisition de nouveaux faits ayant trait à d'autres pays que ceux qui avaient donné lieu à la théorie des espèces arctiques et sub-alpines qui ont provoqué chez moi le doute, mais bien mes observations concernant les pays tropicaux.

Mes travaux sur les Rhizopodes des pays tropicaux et subtropicaux de l'hémisphère sud, m'ont amené à des conceptions de la biogéographie de ces organismes et des protistes en général, tout autres que celles qui prévalaient jusqu'à ce jour. (Voir: „Où en est la protistologie du point de vue de la synécologie et de la biogéographie"). En comparant d'un côté les nouvelles données concernant

la dispersion des Desmidiées et ce que nous savons à ce sujet des Rhizopodes, nous nous trouvons devant les faits suivants:

1. Plusieures espèces de Desmidiées considérées comme arctiques se rencontrent d'une façon normale au Congo belge.

2. Les faits qui ont amené les différents auteurs à considérer un nombre restreint d'espèces de Desmidiées comme arctiques ou alpines, restent vrais, mais les nouvelles données ne permettent plus de parler d'espèces arctiques-alpines.

3. Les espèces dites arctiques ou alpines ne sont pas réparties d'une façon uniforme au Congo belge.

4. La répartition spéciale de ces espèces est en rapport avec l'altitude.

Cette répartition doit être interprêtée d'une façon spéciale (voir conclusions générales).

Examinons ces faits de plus près. En 1935 on pouvait encore considérer comme arctiques-alpines ou à „tendance arctique-alpine", comme je me suis exprimé à ce moment, les espèces suivantes:

Mesotaenium Endlicherianum var. *grande*
Mesotaenium Kramstai
(Cylindrocystis Brebissonii)
(Cylindrocystis Brebissonii var. *minor)*
(Netrium digitus)
(Netrium digitus var. *Naegeli)*
(Penium minutus var. *minor)*
Tetmemorus Brebissonii
(Micrasterias truncata)
(Cosmarium anceps)
Staurastrum bieneanum var. *Spetsbergensis*

Les espèces entre parenthèses sont à tendance arctique-alpine. Un examen de cette liste nous apprend déjà au premier coup d'oeil que les formes entre parenthèses, considérées à tendance arctique-alpine, sont certainement sujettes à caution de ce point de vue.

Or nos nouvelles données nous apprennent que beaucoup des espèces appelées arctiques-alpines se rencontrent dans les pays tropicaux ou subtropicaux, mais alors à des altitudes d'aux moins 1.000 m et le plus souvent au-delà.

En second lieu, les espèces à tendance arctique subalpine se rencontrent parfois à plus faible altitude, mais à de plus hautes altitudes elles se rencontrent en compagnie des espèces dites arctiques typiques, et en plus grand nombre.

* * *

Pour les Rhizopodes j'ai émis des idées au sujet de leur dispersion géographique. La partie de mes conceptions à ce sujet qui nous

intéresse ici, peut être résumée comme suit. L'élaboration d'un système unique de distribution géographique, valable au moins d' un côté pour les plantes, de l'autre pour les animaux, est irréalisable.

Les différents groupes d'animaux et de plantes doivent être étudiés séparément.

Si l'on admet cette façon de voir – et les zoologues qui s'occupent de la dispersion géographique des animaux y sont arrivés depuis plusieurs années – il faut reconnaître que l'opinion sur les espèces arctiques alpines n'est plus soutenable, mais que d'un autre côté la dispersion géographique de ces espèces ne peut être assimilée non plus à celle des Rhizopodes, ni a ancun groupe de plantes supérieures.

Cette dispersion n'est non seulement pas identique, mais elle ne peut être expliquée de la même manière que celle qui nous fait comprendre la dispersion des Rhizopodes.

Nous voyons donc que beaucoup de faits de la dispersion géographique des Desmidiées ne ressemblent pas à ce que nous savons des Rhizopodes. La théorie émise au sujet des Rhizopodes ne peut donc être appliquée aux Desmidiées sans tenir compte des facteurs propres à ces algues.

Examinons d'abord les espèces trouvées dans le matériel de J. J. SYMOENS provenant d'une altitude d'environ 3.000 m., en ajoutant pour chaque espèce toutes les données écologiques et biogéographiques dont nous disposons.

Tout le matériel provient de marais situés à environ 16 km au sud-ouest d'Uvira à une altitude approximative de 3.000 m.

ESPÈCES TROUVÉES

Les espèces que j'ai rencontrées sont les suivantes:

Genre Mesotaenium

N. 1 *Mesotaenium chlamydosporum* DE BARY
N. 2 „ *de Greyi* TURNER
3 „ „ var. *breve* W. WEST
4 „ *Endlicherianum* NAEGELI
N. 5 „ „ var. *grande* NORDSTEDT
N. 6 „ *macrococcum* (KUETZING) ROY ET BISSET

Genre Roya

N. 7 *Roya obtusa* (DE BREBISSON) W. ET G. S. WEST

Genre Cylindrocystis

8 *Cylindrocystis Brebissonii* MENEGHINI
N. 9 „ „ var. *curvata* RABANUS f. *quadripyrenoïdea* n. f.
10 „ *crassa* DE BARY

Genre Tetmemorus

11 *Tetmemorus laevis* (KUETZING) RALFS

Genre Cosmarium

N. 12 *Cosmarium depressum* NAEGELI LUNDELL
N. 13 „ *globosum* BULNHEIM
N. 14 „ *Symoensi* n. sp.

Genre Staurastrum

15 *Staurastrum margaritaceum* (EHRENBERG) MENEGHINI

Toutes ces espèces, 15 au total, sont rares ou manquent complètement dans la partie basse du Congo.

Il y en a plusieurs (8) qui sont nouvelles pour le Congo belge, et une espèce et une forme sont nouvelles pour la science. Comme nouvelles pour le Congo, nous citons les 8 espèces:

— *Mesotaenium chlamydosporum* DE BARY
— *Mesotaenium de Greyi* TURNER
— *Mesotaenium Endlicherianum* NAEGELI var. *grande* NORDSTEDT
— *Roya obtusa* (DE BREBISSON) W. ET G. S. WEST
— *Cylindrocystis Brebissonii* MENEGHINI var. *curvata* RABANUS f. *quadripyrenoïdea* n.f.
— *Cosmarium depressum* (NAEGELI) LUNDELL
— *Cosmarium globosum* BULNHEIM
— *Cosmarium Symoensi* n.sp.

Nous avons donc, sur quinze espèces et variétés mentionnées, huit nouvelles formes pour le Congo dont deux sont nouvelles pour la science.

Genre Mesotaenium

Du genre *Mesotaenium* nous avons trouvé 6 formes, espèces et variétés.

C'est la première fois que dans du matériel d'Afrique tropicale 6 espèces de ce genre se rencontrent ensemble dans un endroit très restreint. C'est même la première fois que six espèces et variétés de ce genre sont mentionnées d'une région limitée. WOODHEAD & TWEED ne citent que *Mesotaenium macrococcum* W. ET G. S. WEST „for the coast of West Africa" Nous-mêmes n'avons rencontré jusqu'à présent que 3 espèces

— *M. Endlicherianum* NAEGELI
— *M. De Greyi* TURNER var. *breve* W. WEST
— *M. macrococcum* (KUETZING) ROY ET BISSETT

Les deux premières à une altitude de plus de 2.200 m, *M. macrococcum* à l'altitude de 925 m.

Nous voyons ici que l'espèce *macrococcum* se rencontre dans les régions tropicales d'Afrique à des altitudes moins élevées que les autres espèces.

Mesotaenium chlamydosporum de Bary (Fig. **1**)

N° de l'échantillon 2108
Mensurations: L. 17μ l. 10μ L/l 1,7

En ce qui concerne la dispersion géographique, nous ne disposons pas encore d'un nombre assez grand de données pour en avoir une opinion. KRIEGER dit: „toute l'Europe, l'Amérique du Nord, les Indes occidentales, l'Amérique du sud, l'Afrique du sud et Bornéo."

Il est étonnant de ne pas voir cité une des îles d'Indonésie dont plusieurs sont déjà assez bien explorées au point de vue des Desmidiées, tandis que précisément Bornéo a été moins examiné que Java et Sumatra.

L'espèce est nouvelle pour le Congo: il est à remarquer que dans le matériel elle fait partie d'une flore presque exclusivement composée de formes arctiques alpines.

Mesotaenium De Greyi Turner (Fig. **2** et **3**)

N° de l'échantillon 2108

Mensurations:	L	l	L/l
	80 μ	18 μ	4,44
	98 μ	24 μ	4,08
	96 μ	24 μ	4
	80 μ	25 μ	3,2
moyennes:	88,5 μ	22,7 μ	3.943

L'espèce est nouvelle pour le Congo belge.

Elle est connue de l'Angleterre, la Hollande, l'Espagne (Galicie), l'Autriche (près de Lunz, mare d'eau de neige), l'Amérique du nord (New Foundland) et de l'Australie (Queensland).

Il est à remarquer que nous ne pouvons pas nous rendre compte de l'abondance ou la rareté dans les différentes contrées, mais certains renseignements sont assez explicites pour nous permettre de conclure qu'il s'agit de biotopes plutôt froids, p. ex. ceux de l'Autriche et de l'Amérique du Nord, et même, quand on connaît les circonstances locales, ceux mentionnés par BEYERINCK pour la Hollande et ceux des Hautes Fagnes belges, (voir VAN OYE) où nous avons trouvé 4 formes du genre *Mesotaenium*. (Les Hautes Fagnes belges ont une faune et une flore microscopiques arctiques alpines.)

Mesotaenium de Greyi Turner var. breve W. West (Fig. **4**)

N° de l'échantillon 2119

Mensurations: L. 46 μ l. 20 μ Extr. 16 L/l 2,3

Espèce déjà rencontrée au Congo par VAN OYE dans le matériel de J. LEBRUN n° 8537 à une altitude de 2.226 m.

En 1943, j'ai fait la remarque que jusqu'à ce moment (1943) cette forme n'avait pas encore été rencontrée dans un pays tropical. La présente étude donne une explication de ce fait. L'exemplaire mesuré en 1943 avait une longueur de 42 μ et une largeur de 17 μ, ce qui donne pour la L/l: 2,47. Cette variété était connue des Iles britanniques, de la France, de la Suède, de Nowa Semlja et du Massachusetts (Amérique du nord).

Mesotaenium Endlicherianum Naegeli (Fig. **5**)

Habitat n° 2110

Mensurations:	L.	l.	L/l
	30 μ	12 μ	2,5
	33 μ	11 μ	3

Cette espèce est déjà mentionnée du Congo belge par VAN OYE en 1943 dans le matériel de J. LEBRUN, provenant d'une altitude de 2.226 m.

L'espèce est mentionnée, mais sans indication d'altitude, d'Europe, de Java, de Bornéo, de l'Amérique du nord, et du sud du Chili.

Quant au pH auquel cette espèce a été trouvée, KRIEGER mentionne 4,89—5,16.

Le pH de l'eau des sphaignes dont provient le matériel était 3,8.

Mesotaenium Endlicherianum Naegeli var. grande Nordstedt (Fig. **6**)

Habitat n° 2110

Mensurations: L. 71 μ l. 13 μ L/l 5,46

Cette variété est nouvelle pour la flore desmidiale du Congo belge.

Cette espèce n'a pas encore été trouvée dans un pays du continent africain. Sa dispersion géographique se confine, pour autant que les données actuelles permettent de conclure, à l'hémisphère nord.

Je fais remarquer que j'emploie ce terme purement dans son sens géographique, je ne puis accepter une dispersion géographique de l'hémisphère nord d'un côté et de l'hémisphère sud de l'autre. (voir VAN OYE: Au sujet de la distribution geographique des Rhizop. *Biol. Jaarboek* 1944).

Mesotaenium macrococcum (Kuetzing) Roy et Bissett (Fig. **7**)

N° de l'échantillon 2108

Mensurations L 22 μ l 10 μ L/l 2,2

Cette espèce était connue du Congo belge.

Elle a été trouvée par VAN OYE en 1943 dans le matériel de LEBRUN. L'échantillon provenant de l'eau retenue dans les rosettes de Pistia. La seconde fois que je l'ai trouvée était dans du matériel provenant d'une mare le long du chemin de Matidi vers Seke Banze. Cette contrée est accidentée et couverte de bois et de petites savannes. En 1947 j'ai déjà fait la remarque que la présence de *Mesotaenium macrococcum* dans le matériel du Bas-Congo était encore inexplicable.

Aucune nouvelle donnée n'est venue éclaircir ce problème. BOURRELLY (W. KRIEGER & P. BOURRELLY) dans le travail sur les Desmidiées du Vénézuéla dit: Espèce subaerienne, acidophile, plus ou moins montagnarde.

KRIEGER dit de cette espèce: Dans toute l'Europe, spécialement dans la région montagnarde et le Nord de l'Europe.

Roya obtusa (de Brebisson) W. et G. S. West. (Fig. 8)

N° de l'échantillon 2108
Mensurations L 105 μ 1 20 μ Extr. 10 μ L/1 5,25

La présence de *Roya obtusa* (DE BREBISSON) W. ET G. S. WEST au Congo et surtout dans le milieu où nous l'avons trouvée, est des plus étonnantes et sujette à caution.

Non seulement au point de vue systématique, mais aussi au point de vue écologique et biogéographique, sa présence dans le matériel examiné est très douteuse.

Elle est connue de l'Europe, de l'Amérique du nord, du Brésil, de la Chine du sud et de Java.

Je doute avoir affaire à *Roya obtusa* (DE BREBISSON) W. ET G. S. WEST.

Mais même la distribution d'après les données de la littérature nous fait douter aussi quant au fait si nous ne nous trouvons pas devant des erreurs de détermination. Aussi longtemps que ce point n'est pas éclairci, nous devons accepter les données et avouer qu'on ne peut en tirer aucune conclusion. Nous ne pouvons que résumer le tout en disant: forme cosmopolite dont la distribution géographique, pour autant qu'elle est connue, cause le plus grand étonnement.

Cette espèce est nouvelle pour la flore desmidiale du Congo belge.

Cylindrocystis Brebissonii Meneghini (Fig. 9)

N° de l'échantillon 2108

	L	1	Extr.	L/1
Mensurations:				
	68 μ	22 μ	18 μ	3,09
	60 μ	20 μ	18 μ	3

Espèce déjà mentionnée du Congo belge par VAN OYE, une première fois en 1943 dans le matériel de LEBRUN provenant de marais de Kikeri au nord du lac Kivu, à une altitude de 2.226 m.

A cette occasion j'ai dit: Espèce cosmopolite mais nettement sténotope.

En 1949 je l'ai trouvée dans du matériel de BERVOETS récolté dans un marais peu profond situé sur la route Seke-Banze à environ 60 km au Nord-est de Matadi. A ce moment j'ai fait la réflexion suivante: „. . . le nombre d'exemplaires rencontrés était très minime, j'ai observé en tout deux exemplaires de cette espèce".

KRIEGER dans son travail sur les Desmidiées „der deutschen limnologischen Sunda-Expedition" l'a trouvée à une altitude de 1.500 m. Il dit: „in den Tropen naturgemäss nur in höheren Lagen". Mais KRIEGER dit „naturgemäss" parce qu'il croyait que les biotopes dans lesquels cette espèce vit, ne se rencontrent dans les pays tropicaux qu'à de grandes altitudes. Or, ici il se trompe. Dans les pays tropicaux, les biotopes où *Cylindrocystis Brebissonii* peut se présenter, existent parfois aussi dans les régions basses, comme le prouvent mes observations sur le matériel de BERVOETS. KRIEGER & BOURRELLY „Desmidiées du Vénézuéla" la citent des altitudes de 3.600 à 3.800 m. Dans leur texte nous lisons: „à tendance montagnarde". L'expression de BOURRELLY est bonne: „à tendance montagnarde", mais elle n'explique rien, et est aussi applicable aux régions à climat tempéré.

Cylindrocystis Brebissonii Meneghini var. curvata Rabanus f. quadripyrenoïdea n.f. (Fig **10** et **11**)

N° des échantillons: 2108, 2110

Mensurations:	L.	l.	L/l
	75 μ	25 μ	3
	77 μ	23 μ	3,3

La nouvelle variété se distingue de la forme connue, uniquement par la présence constante de deux pyrenoïdes par demie cellule.

La variété *curvata* de RABANUS n'est connue que de la Forêt Noire en Allemagne.

Cylindrocystis crassa de Bary (Fig. **12**)

Habitat 2110

Mensurations: L. 33 μ l. 18 μ L/l 1,83

Cette espèce a déjà été mentionnée au Congo belge par VAN OYE en 1949. A ce moment j'ai fait la remarque: „Le fait que cette espèce a été rencontrée si peu jusqu'à présent au Congo belge, mérite l'attention, car elle n'est nullement rare en Europe et a déjà été rencontrée dans d'autres pays tropicaux".

Krieger dans: Rabenhorst „Die Desmidiaceen Europas", en 1933, résume les données de la littérature comme suit: Surtout en Europe et Amérique du nord, a été fort peu trouvé au delà du cercle polaire (la partie nord du Canada et le nord de la Norvège). Dans les tropiques, à des altitudes plus élevées, (l'ouest de l'Afrique, Bornéo, Singapore, l'Asie centrale, le nord de l'Inde, l'Afrique du Sud, la Nouvelle-Zélande, les îles Orkney du sud, Grahamland.

Les données que nous apportons n'éclaircissent nullement le problème de la dispersion géographique de cette espèce. Le pH de nos échantillons était 3.8, ce qui confirme la conclusion que cette espèce vit à un pH très bas. En effet, Strøm & Feher l'avaient trouvée à un pH de 4.5—6.

Tetmemorus laevis (Kuetzing) Ralfs (Fig. **13** et **14**)

n° des échantillons: 2108, 2110

Mensurations:	L	l	Is	Extr.	L/l
	97 μ	23 μ	20 μ	14 μ	4,21
	91 μ	23 μ	19 μ	18 μ	3,95
	96 μ	23 μ	19 μ	17 μ	4,17
	88 μ	22 μ	19 μ	18 μ	4,—
	100 μ	24 μ	20 μ	20 μ	4,17
	85 μ	24 μ	20 μ	14 μ	3,54
	100 μ	24 μ	20 μ	18 μ	4,16
	100 μ	24 μ	19 μ	15 μ	4,16
	92 μ	22 μ	19 μ	16 μ	4,18
	88 μ	21 μ	19 μ	13 μ	4,19
	81 μ	21 μ	19 μ	15 μ	3,85
	98 μ	23 μ	19 μ	15 μ	4,26
	86 μ	24 μ	20 μ	18 μ	3,58
	85 μ	22 μ		10 μ	3,72
	92 μ	23 μ		14 μ	4,—
	94 μ	22 μ	18 μ	15 μ	3,8
moyennes	87 μ	22,8 μ			3,875

Elle était assez commune dans le matériel du sud-est d'Uvira. Kufferath cite cette espèce du Bas-Congo avec la mention: „Tous ces échantillons sont d'origine aquatique".

Krieger dit concernant cette espèce: „In den Hochgebirgen bis zur Schneegrenze".

D'après cet auteur, cette espèce est citée de toute l'Europe, le Grönland, le nord des pays scandinaves, la Finlande, l'Asie, Tomsk et Singapore, l'Australie (Nouvelle-Zélande), la Nouvelle Calé-

donie, l'Afrique, le Pays du Cap et le nord de l'Afrique, les Açores, les Kerguèles, l'Amérique du nord, New Foundland, l'Alaska, le Canada, les Indes occidentales, l'Amérique du sud, le Vénézuéla, le Brésil.

Comme on le voit, une espèce des plus cosmopolites connues. Combien ne serait-il pas intéressant de pouvoir examiner cette dispersion en détail, mais faute de données précises il est absolument impossible de le faire.

La question se pose si elle ne présente pas de races géographiques. Dans tous les cas pour le moment il faut la considérer comme cosmopolite et euryionoque, pH de 3,8—7.

Cosmarium depressum (Naegeli) Lundell (Fig. **15**)

N° de l'échantillon: 2112

Mensurations:	L	l	Is	L/l
	30 μ	33 μ	11 μ	0,90
	28 μ	34 μ	10 μ	0,82

Espèce nouvelle pour le Congo belge.

Nos exemplaires sont un peu plus petits que l'espèce type, mais plus grands que la variété *minor* West.

Comme ils se rapprochent cependant, en ce qui concerne les dimensions, plus du type que de la variété, je n'hésite pas à considérer les exemplaires trouvés comme appartenant au type.

Notons en passant que le manque de données précises ne nous permet pas d'examiner si le rapport entre la longueur et la largeur est le même pour la variété et le type ainsi que pour les espèces de provenance différente.

Notons que W. et G. S. West mentionnent la ressemblance avec *Athrodesmus convergens* Ehrenberg sans épines, et rappellent à ce propos que Jacobsen rattache *C. depressum* à *Athrodesmus convergens* comme variété „*inermis*".

Il faut faire remarquer ici qu'*Arthrodesmus convergens* Ehrenberg est connu du Congo belge.

D'autre part, dans l'étude des Desmidiées du Kraenepoel en Belgique, étude faite avec le concours de Fr. Evens, j'ai fait la remarque suivante au sujet d'*Anthrodesmus*: „Concernant le polymorphisme de cette espèce, M. Fr. Evens a examiné dans une pêche plusieurs individus et en a fait une série très importante de figures, qui prouvent que, dans le même milieu à la même époque et au même endroit, on peut trouver simultanément la forme typique avec les épines, la forme sans épines, même sans aucune indication d'épines, et toutes les formes de transition. Il est certain que la forme sans épines ressemble plus à une espèce du genre *Cosmarium* qu'à une *Arthrodesmus*."

Dans le cas des exemplaires que j'ai rencontré dans le matériel de M. SYMOENS, il faut remarquer que la plupart présentaient de petites pointes tendant vers des ébauches d'épines. Malgré la façon catégorique avec laquelle les WEST expriment leur opinion: „In fact, the ressemblance between *A. convergens* and *Cosm. depressum* is so very close that many suggestions have been made as to their specific identity. T h e s e s u g g e s t i o n s a r e, h o w e v e r, b a s e d u p o n i n s u f f i c i e n t k n o w l e d g e o f t h e s e D e s m i d s", je dois avouer que les faits que j'ai observé dans la nature me font douter de l'exactitude de l'opinion des WEST. Malheureusement, seules des études expérimentales très approfondies peuvent donner une réponse définitive à cette question.

Concernant la distribution géographique, il ne me reste qu'à répéter ce que j'ai dit en 1941: espèce très commune, cosmopolite.

En rapport avec notre conclusion déduite de l'étude du matériel de M. SYMOENS, la présence de *Cosmarium depressum* ne peut être prise en considération pour plusieurs raisons. D'abord *C. depressum* semble une forme cosmopolite, ensuite elle a des rapports si étroits avec d'autres espèces que nous ne pouvons pas nous baser avec certitude sur toutes les données de la littérature, vu que des erreurs de détermination sont très probables.

Cosmarium globosum Bulnheim (Fig **16**)

N° de l'échantillon: 2.108
Mensurations: L 30 μ l 23 μ Is 19 μ L/l 1,30

Espèce nouvelle pour le Congo belge.

Elle présente une distribution géographique englobant presque toute la terre. Elle était connue de l'Est de l'Afrique.

SCHMIDLE l'a signalée des Alpes ainsi que dans la région du Kilimandjaro à une altitude de 3.750 m.

Cette espèce, pour autant que la littérature nous permet de juger, semble à tendance montagnarde.

Cosmarium Symoensi n. sp. (Fig. **17** et **18**)

N° des échantillons: 2112, 2119

Mensurations:	L	l	Is	L/l
	52	34	30	1,52
	53	30	26	1,76
	51	33	26	1,54
	52	34	29	1,52
	52	33	27	1,54
moyennes	52	32,8		1,572

De toutes les espèces de *Cosmarium* qui ressemblent plus ou

moins à la forme que j'ai rencontrée en assez grand nombre dans le matériel de SYMOENS, il y en a aucune avec laquelle j'ai pu l'identifier.

Le facies est déjà tout différent, mais à part cela, elle se distingue par sa taille de toutes les formes avec lesquelles on pourrait la comparer.

Cette espèce a un pyrénoïde par demie cellule.

Les demi-cellules sont arrondies à la base sans angles spéciaux ni protubérances. Le sinus est largement ouvert.

Staurastrum margaritaceum (Ehrenberg) Meneghini (Fig. **19**)

Habitat: 2119

Dimensions: L. 40 μ l. 29 μ Ism. 5

L'espèce *Staurastrum margaritaceum* (EHRENBERG) MENEGHINI a été mentionnée du Congo belge par DE WILDEMAN en 1889 et par VAN OYE en 1942.

C'est une espèce absolument cosmopolite. Comme telle, sa présence au Congo belge n'offre rien d'étonnant. A en juger d'après la littérature, elle est également ubiquiste.

CONCLUSIONS GÉNÉRALES

Rappelons-nous d'abord que toute flore, algologique ou autre, se compose d'éléments de provenance différente.

Nous pouvons considérer les trois groupes: autochtones, nouveaux-venus et relictes, comme les plus importants. Une flore doit être considérée arctique quand elle contient d'une façon plus ou moins prédominante un certain nombre d'espèces qui se rencontrent dans les régions arctiques. A côté de ces espèces on peut trouver un certain nombre d'autres formes, ou bien cosmopolites ou venues des régions voisinantes ou même accidentelles. Tous les cas doivent être examinés sur les lieux en rapport avec l'écologie du milieu, en rapport aussi avec les régions qui entourent la partie dont on examine la flore, ainsi qu'avec ce que nous savons des autres contrées, si éloignées qu'elles soient. Ce qui rend pour le moment tout jugement très difficile, est que non seulement tous les cas connus doivent être examinés en détail, mais que très souvent il nous manque les données les plus simples pour comprendre ce qui à première vue semble être inexplicable.

Un exemple typique en rapport avec le problème qui nous occupe ici. En parcourant la liste des Desmidiées connues de la Belgique, nous y trouvons plusieurs des espèces dites arctiques-alpines, alors que la Belgique a un climat de zone tempérée et que le point le plus élevé du pays n'atteint pas même 700 m.

Ces espèces font partie d'une flore et faune spéciale dans la région des Hautes Fagnes où l'on trouve en effet des représentants d'une flore et d'une faune arctique-alpine.

Le fait de rencontrer dans la flore Desmidienne des Hautes Fagnes, des espèces arctiques-alpines, suffirait à conclure que ces espèces sont considérées à tort, non seulement comme arctiques-alpines, mais même comme subarctiques ou subalpines. Or, les études de L. Frédericq ont prouvé que la région belge dite alpine, héberge un assez grand nombre de plantes et d'animaux macroscopiques appartenant aux faunes et flores des régions plus nordiques.

A cette constatation j'ai pu ajouter une série de protistes et entre autres des Desmidiées reconnues comme arctiques ou subarctiques.

Ce sont des circonstances purement locales qui entrent en jeu ici, et la présence de ces espèces en Belgique n'est nullement en contradiction avec leur caractère arctique. L'explication a été donnée par L. Fredericq qui a démontré que ce sont des relictes de l'époque glacière.

La petite florule Desmidienne que j'ai rencontrée dans le matériel de Symoens a également un caractère nettement arctique.

Or cette florule se trouve au milieu d'un pays tropical. Voilà ce qui est très étonnant et qui mérite qu'on s'y attarde.

A première vue on est tenté de rapprocher la dispersion géographique de ce petit groupe de Desmidiées à la distribution géographique des Rhizopodes telle que je l'ai mise en lumière et expliquée à différentes reprises. En parcourant la distribution géographique des Desmidiées dites arctiques ou subarctiques et celle des espèces que j'ai appelées à tendance arctique, nous voyons une distribution toute différente.

En grandes lignes nous voyons que les Desmidiées arctiques se rencontrent surtout dans toutes les parties du nord de l'Amérique, du nord de l'Europe et en Asie. Ce qui est en opposition absolue avec la dispersion des Rhizopodes Nebellides.

D'un autre côté, leur dispersion en Afrique centrale est en accord avec celle des Nebellides, c.à.d. on les rencontre surtout, voire même presque exclusivement à des altitudes dépassant 1500 m, c.à.d. où les circonstances climatériques commencent à présenter des points communs avec les climats tempérés, ou froids et cela surtout en ce qui concerne les biotopes dans lesquels on trouve ces espèces, notamment le sphagnum. Voilà deux points acquis, mais contradictoires:

1. La différence complète de distribution géographique dans le monde avec la distribution des Rhizopodes, surtout des Nebellides et,
2. La concordance de distribution et de biotopes au Congo belge.

En 1954 j'ai exposé mes idées de ce moment dans „Sur la distribution des algues".

A cette occasion j'ai dit: „Toutefois il faut reconnaître que, si nous avons pu démontrer que la dispersion géographique des Rhizopodes, tout en étant propre à ces organismes, n'est cependant pas en contradiction avec les lois et règles de la biogéographie générale, nous n'en sommes pas encore aussi loin quant à la distribution géographique des algues. Car, si les faits connus jusqu'à présent nous forcent à admettre une dispersion géographique des protophytes, nous n'avons encore aucune idée de la façon dont elle se présente. Il semble que celle des Desmidiées est en grandes lignes analogue à celle des Rhizopodes pour laquelle je renvoie à mon étude: „Au sujet de la distribution géographique des Rhizopodes" paru dans „*Biologisch Jaarboek Dodonaea*" 1944, II, 83—91:

„Néanmoins, nous pouvons et nous devons dès à présent – en nous basant sur l'évolution des faits, des idées et des méthodes employés pour les Rhizopodes – admettre que dans un avenir prochain une distribution géographique des algues sera unanimement admise par tous les algologues."

Depuis que ces lignes ont été écrites (1954) j'ai eu l'occasion d'examiner bon nombre d'échantillons de matériel de provenances diverses.

En 1956 je suis revenu sur cette question en examinant „La distribution géographique des Rhizopodes" et j'en suis arrivé à une nouvelle conception de la biogéographie des êtres inférieurs.

En tenant compte des nouvelles données exposées dans le présent travail, j'en viens à la conclusion que j'ai eu tort d'admettre à priori comme probable une similitude de la dispersion géographique des Rhizopodes et des Desmidiées. En ce qui concerne les groupe des Desmidiées dites arctiques-alpines, la différence est nette.

Le groupe des Desmidiées arctiques-alpines est certainement d'origine nordique. Les expèces de ce groupe ont avancé, durant les époques géologiques propices, jusque dans certains pays actuellement situés sur l'équateur. Elles s'y sont maintenues dans les parties qui par leur altitude ont conservé un climat froid.

Tout comme la plupart des Nebellides qu'on rencontre au Congo, on doit les considérer comme des relictes de temps géologiques très reculés, mais d'une toute autre origine, et l'époque géologique de leur dispersion doit se situer chronologiquement après celle des Nebellides.

Comme conclusion générale, nous devons dire qu'on ne peut parler de la dispersion des protistes comme d'un ensemble, pas plus qu'on ne peut parler de la dispersion des vertébrés sans distinguer des classes indépendamment les unes des autres.

Au moment où les Rhizopodes Nebellides envahissaient l'énorme bloc continental américain africain asiatique australien, les Desmidiées du groupe arctique ont peut être apparu dans les parties actuellement au nord de l'équateur.

Après la séparation de l'Afrique du vaste continent du sud actuel, les Desmidiées du groupe arctique se sont dispersées vers le sud et, à la suite de la configuration des continents à cette époque, aussi en Afrique.

Lors des changements climatériques postérieures, les formes arctiques n'ont pu se maintenir qu'aux altitudes offrant des conditions écologiques propices. La florule arctique rencontrée dans le matériel examiné est donc à considérer comme une florule de relictes.

De matériel provenant de sphagnum de la région du Bas-Congo nous montre par ailleurs une florule desmidiale d'un tout autre aspect, ce qui est en concordance avec notre conclusion.

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The growth of Tilapia esculenta Graham in Lake Victoria

by

D. J. Garrod

East African Fisheries Research Organisation, Jinja, Uganda

INTRODUCTION

Tilapia esculenta is endemic to Lake Victoria but in recent years the species has been used to stock fish ponds and reservoirs in many parts of East Africa. Subsequent observations upon these introduced fish populations have shown that the growth of *Tilapia esculenta* is extremely variable; in aquaria fish may mature when ten centimetres long and five months old, whereas in Lake Victoria the onset of breeding occurs between twenty and twenty five centimetres of length at the probable age of two to three years. Other species of *Tilapia* show similar variability, the extreme example being *T. nilotica* which is found in Lakes George, Edward and Albert and in Albert Nile system, and in Lake Rudolf, and which has also been introduced into many reservoirs, each population having apparently different growth rates. (Lowe-McConnell, 1958).

The growth rates of fish that have been introduced into artificial lakes, compared with that of the parent stock, indicate that the growth of *T. esculenta* is very sensitive to environmental conditions. This study describes the growth of this species in Lake Victoria only.

Estimation of the growth rate of fish in tropical waters is more difficult than that of fish in temperate lakes: the seasonal environmental fluctuations, which in temperate waters cause the formation of 'annual' rings on skeletal structures, are less marked and do not appear to affect the growth rate of the fish. Furthermore fish are capable of breeding throughout the year so that individuals cannot be assigned to discrete year classes.

In recent years the growth and age of *T. esculenta* in Lake Victoria have been estimated by the following methods.

1) Marking Experiments.

Marking experiments, using opercular tags, have been carried out by the Lake Victoria Fisheries Service. Of the fish recaptured only 48% had been free for a sufficiently long period to show appreciable growth. Of these, 50% showed no growth or even a reduction in length. Results from fish that had grown a significant amount were variable, and it is clear that the form of tagging had a serious physiological effect on the fish. This might be expected since *T. esculenta* is afilter feeder and opercular clips may interfere with the respiratory and feeding current.

2) Petersen's Method

PETERSEN's method of age determination, by analysis of the length frequency distributions of catches at different times of the year, has also given poor results because fish are capable of breeding throughout the year. Together with the apparent range of size at a given age this causes the progression of modal size frequencies to be poorly defined. LOWE-MCCONNELL (1956) obtained some indication of the growth of juveniles using this method and further evidence on the growth of the young was derived from the length frequency distribution of fish taken in a seine net hauled regularly at Kisiani, in the Kavirondo Gulf, during 1950—1951.

i) Observations of LOWE-MCCONNELL (op. cit.)

a) Using a mosquito net seine in swamp channels in the vicinity of Jinja, LOWE-MCCONNELL was able to trace a progression of the modal size of the population which suggested that, during the first year of growth, individuals of this species may grow as much as 14—17 centimetres. The actual observations showed a mode at 12.5 cm. after one year of growth, but, since at this time the fish move into more open water, she suggested that the observed modal length represented a minimal growth rate.

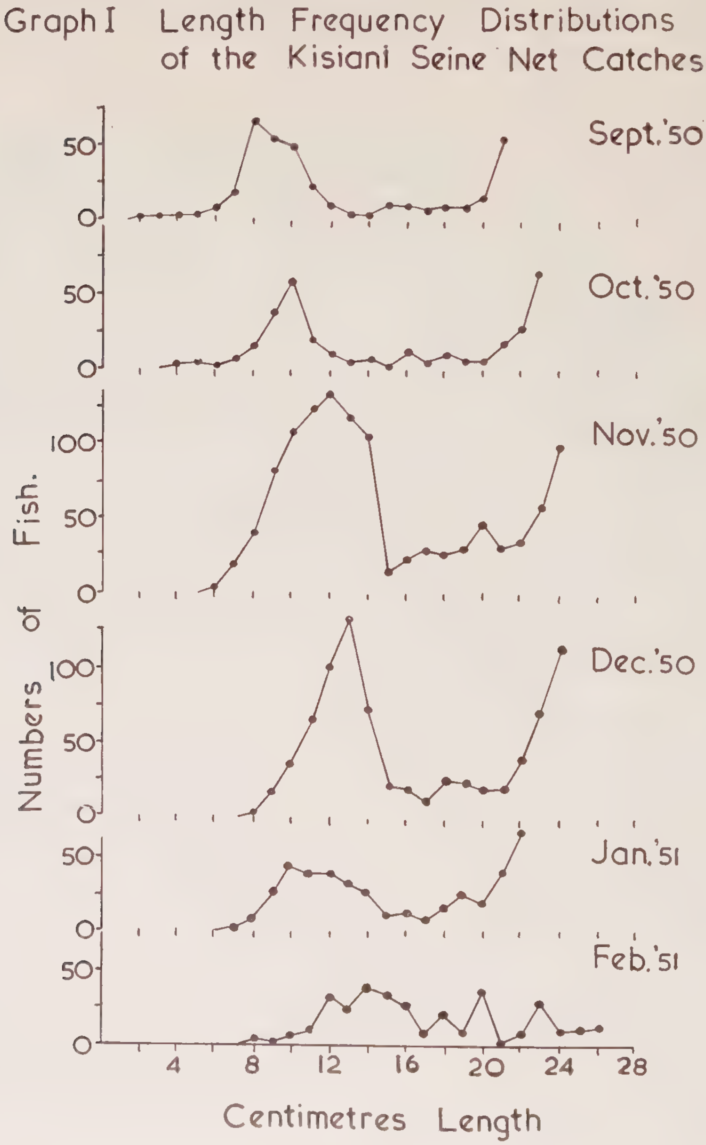
b) LOWE-MCCONNELL also observed that at Mwanza, on the Tanganyika shores of Lake Victoria, juvenile fish at a modal size of 15 cm. appear on the coastline annually between October and December. She was not certain whether these represented young from broods raised during the previous April (the breeding season on the coast slightly further north), or from the October-December period of the previous year (the breeding period of the population of the Smith Sound area adjacent to the beaches where these data were collected), but suggests that the relevant breeding season is most likely to be that of the Smith Sound area, i.e. one year old fish would be 14—17 cm. long.

During the breeding season of May 1949 LOWE-MCCONNELL observed modal size frequencies at 24, 29, and 31 cm. in the *T. esculenta*

catches in the Speke Gulf, east of Mwanza. Assuming these modes to represent growth between the breeding seasons she concluded that at two years old these fish may reach 20—23 cm., at two and a half years 24 cm., at three years 26 cm. and at three and a half years 29 cm.

ii) Data from the Kisiani Seine.

The data in Graph I show that in the Kavirondo Gulf area juvenile *T. esculenta* may grow from eight to fourteen centimetres of length



in six months although the age of the fish when they first appeared on the beaches is not known. However, they first appeared in September and it seems most probable that they were spawned in the previous peak period of breeding activity in April and May, (Lowe-McConnell, op. cit.). Thus an eight centimetre fish would be approximately six months old giving a total growth of fifteen centimetres in the first year.

3) **Growth in Aquaria.**

Fish reared in aquaria, and in live boxes in Lake Victoria, have shown variable growth patterns that cannot be directly compared with the growth of 'wild' fish.

4) **Ring Formation on Otoliths.**

No rings were observed on natural or histologically prepared otolith samples, although rings were present on the scales of the same fish.

5) **Ring Formation on the Opercular Bones.**

Samples of opercular bones were found to bear complex markings that could not be related to the rings observed on the scales of the fish sampled.

6) **Ring Formation on Scales.** (PLATE I)

The covered, i.e. anterior, portion of the scales of *T. esculenta* is sub-divided by radii from the focus of the scale. This area is traversed by a series of regular circuli which may become irregular or discontinuous. A complete arc of such disfigured circuli forms a ring which may vary in its degree of definition depending upon the number of circuli which enter into its formation.

Holden (E.A.F.R.O. Annual Report 1956) has shown that in both *T. esculenta* and *T. variabilis* (a second species of *Tilapia* endemic to Lake Victoria) the occurrence of rings is correlated with gonad maturity. In the former species rings are also laid down by the immature fish though these are less well defined than those of the mature fish. Holden suggests that ring formation in the mature fish may be associated with loss of condition during the breeding period; *T. esculenta* is a mouth brooding species and 'running' and 'recently spent' fish are known not to feed, (Lowe-McConnell, op. cit.).

Breeding *T. esculenta* may be found throughout the year but it is believed that individual fish undergo breeding periods, when a succession of broods are produced, followed by a resting period. This point is discussed more fully below.

In this study scales were taken from samples of fish from the Jinja area, the Kavirondo Gulf area and the Mwanza area. The pattern of

PLATE I

T. esculenta. Flank scale of 31.2 cm. male from the Mwanza area.
* Rings representing breeding periods.
⊙ Ring laid down during the juvenile phase of the life history. No significance can be attached to the position of this ring in relation to the position of the 'breeding' rings. (See E.A.F.R.O. Annual Reports)

ring formation has been determined by calculating the lengths at which successive rings were laid down. From these data, estimates of the growth of *T. esculenta* in different parts of Lake Victoria have been obtained on the hypothesis that each ring represents a breeding period and that two such periods occur annually.

METHOD

A preliminary survey of scales taken from individuals caught by routine gill-netting in the Jinja area showed that the scales from any part of the body have a variable number of circuli but that the pattern of ring formation is constant on all the scales of a single individual, although the rings vary in the degree of definition.

Three scales were taken from each fish, one from the epaxial shoulder region, one from the hypaxial flank, and a third from the hypaxial caudal region. Each scale, when taken, was examined with the naked eye in order to estimate whether erosion, which sometimes occurs, would interfere with accurate reading of the scale. Eroded scales were discarded and replaced by the corresponding scale from the other side of the fish, or by an adjacent scale.

The total length of the fish to the nearest millimetre, measured to the extreme tip of the dorsal edge of the caudal fin, was recorded together with a visual estimate of the sexual state of the gonads. For fish from the Jinja area the weight in ounces was also recorded.

The scales were then mounted in water and examined under low power with a monocular microscope; measurements were carried out using a hairline graticule in the eyepiece and a moving stage. The shortest distance from the focus of the scale to the anterior edge of the scale was measured, i.e. the length of the area sub-divided by regular radii, and also the distance to the point of origin of each ring from the focus of the scale on the same axis. Rings were laid down by immature fish (Holden, op. cit.) but these are less discrete than breeding rings and are not laid down in a regular series. Only the breeding rings of mature fish were measured in this instance. Measurements were recorded in graticule units.

Scales from three hundred and ninety five (395) fish of between 20 and 35 cm. were examined from the Jinja area, and a further two hundred and eighty one (281) varying from 20 to 40 cm. from the Kavirondo Gulf area. Of the latter, two hundred and twenty three (223) came from within the Gulf and fifty eight (58) outside. A further sample of seventy seven fish (77) was collected at Mwanza, Tanganyika. The samples were obtained by gillnets in the Jinja and Mwanza areas, and by seining and gill-netting in the Kavirondo Gulf. In addition the scales of two hundred and twenty (220) fish ranging from 1—20 cm. were examined in order to obtain a scale length/body length relationship over the complete size range of *T. esculenta*, with which to calculate the lengths at which ring formation had occurred.

It was found that in some cases the focus of the scale was abnormal, or sufficiently eroded to prevent accurate measurement; in a few specimens the scales of the caudal region were all so badly eroded that it was not possible to take a satisfactory sample. Results were only used for the final analysis where accurate measurements were possible on at least two of the scale samples. Where the caudal scale was badly eroded at the centre only, the rings were counted as a check against the other two scales without being measured.

The scale length/body length relationship was different for each of

TABLE I

THE SELECTION OF SCALES USED IN THE ANALYSIS

Origin of sample	Total	Only I	Number Discarded, Immature or		Num
	Number	scale readable	I ring only	Others	Analy
Jinja (Uganda)	395	50	51	14	280
Kavirondo Gulf (Kenya)	281	30	43	—	208
Mwanza (Tanganyika)	77	1	6	5	65

the areas of the body from which the scales were taken; thus three separate estimates of the length at which ring formation occurred were obtained for each fish.

The final pattern of ring formation in an individual fish was the average length as calculated from corresponding rings on the three different samples of scales. In some instances a ring was observed in the series on only one scale of the sample; these were included in the final pattern of that fish since the factors responsible for ring formation were not fully understood and it is possible that rings other than breeding rings have been included. It was hoped that this proportion of non-breeding rings would be sufficiently small not to affect the final analysis.

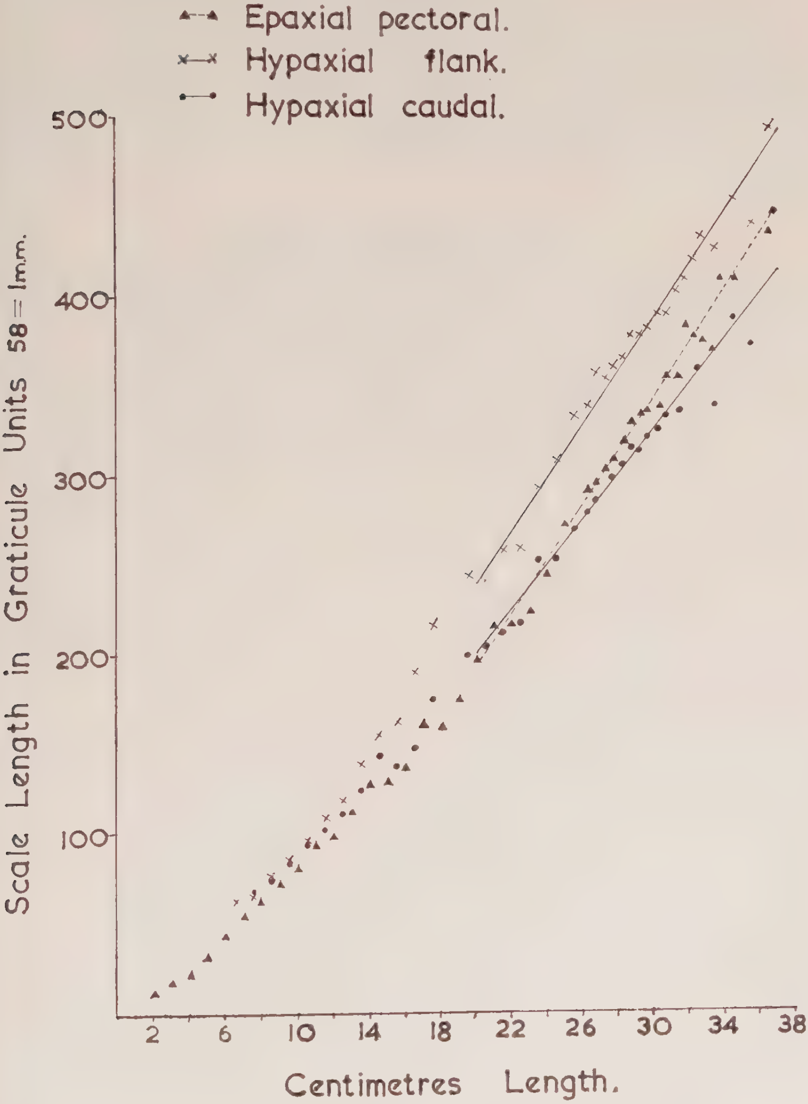
The data from the four areas were analysed separately. The samples from the Jinja area and from within the Kavirondo Gulf area were classified into single centimetre groups according to the length at first breeding, and also according to the number of observed rings, thus giving groups of fish that had bred initially in the same season. The small samples from outside the Kavirondo Gulf and from the Mwanza area were analysed as single groups.

RESULTS

Graph II shows the scale length/body length relationships for the three areas of the body from which the scales were taken. The relationship is clearly non-linear in immature fish. Scales become macroscopically visible at approximately 1.3 cm. of body length. (The scale length/body length relationship of the scales from the epaxial shoulder region against the total length, standard length and the moulded length, i.e. the horizontal surface length of the body, were examined in earlier work but all were found to be non-linear in the juvenile fish.)

The lengths at which ring formation occurred in a fish of a given length were calculated from the following formula:

Graph II The Body Length / Scale Length Relationships.



[1] $$\frac{\text{Average scale length}}{\text{Observed scale length}} \times \text{Observed position of ring} = \text{True position of ring}$$

The calculation was carried out in graticule units and the position of the ring then read from Graph II.

During the analysis it was found that there was no significant difference in the growth rates of the males and females and in the data presented in Table II below the sexes have been considered together.

GENERAL CONSIDERATIONS

The data in Table II can be interpreted as growth indicators on the hypothesis that each ring represents a period of breeding activity and that breeding occurs at definite intervals of time.

In temperate waters 'annual' rings are laid down on the scales of fish as a result of seasonal fluctuations in temperature, food supply and possibly light. The 'annual' rings on the scales of the Roach become visible when growth is renewed in the spring, (WALLIN, 1957).

In Lake Victoria water temperatures vary between c.a. 23 C and c.a. 27° C, and are minimal during June, July and August, suggesting, by analogy, that at this time growth would be least. However *T. esculenta* is herbivorous, feeding almost entirely upon phytoplankton which FISH (1957) has shown to be abundant throughout the year in typical *T. esculenta* habitats: furthermore LOWE-MCCONNELL (op. cit.) observed that during the cool season *T. esculenta* are feeding particularly well, although there is no evidence on the possible seasonal variations in the nutritional value of the plankton. Thus in Lake Victoria, of the two factors, temperature and food supply, which are primarily responsible for ring formation in the scales of fish in temperate waters, only temperature shows a decline.

Prior to the cool season there is a peak period of gonad activity coinciding with the rainy season (in the Jinja area). At this time the proportion of 'ripe', 'running' and 'recently spent' fish in the catches increases. As has been noted above, these fish are fasting and it is to be expected that a growth check might occur at this time. It has also been shown that at this period the calcium metabolism of the body fluctuates, (NEWELL & GARROD, 1958).

The hypothesis that scale rings are related to breeding activity rather than seasonal fluctuations in the environment is further sup-

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[1]) The scale length as shown in Graph II of fish of the size from which the sample under examination was taken.

TABLE II

average lengths at which successive rings were formed (fish classified according to the length at first breeding.)

Brackets indicate where sample had declined to only one fish.

A. *JINJA AREA*

entimetre of Body ,ength at t Breeding	No. of Fish	Body Length at Ring Number 1	2	3	4	5	6	7	8	9	10	11	12	13
—18.9	2	18.8	21.8	24.5	25.7	27.4	28.0							
—19.9	10	19.6	21.7	23.2	24.1	24.8	25.7	26.6	27.0	27.4	28.1			
—20.9	37	20.5	22.7	24.3	25.4	26.4	26.9	27.9	28.8	29.0	29.4	(27.3)		
—21.9	44	21.5	23.5	24.7	25.6	26.7	27.3	28.4	28.9	27.7	(28.9	29.2)		
—22.9	47	22.2	24.2	25.6	26.4	27.5	28.4	29.6						
—23.9	55	23.5	25.1	26.4	27.4	28.4	29.2	29.9	30.0	(28.0	28.7	29.2	29.8	30.2)
—24.9	46	24.4	25.9	27.0	28.2	28.5	28.7	29.5	30.5					
—25.9	22	25.4	26.7	27.8	28.6	29.5	30.9	31.0	31.9	(32.2	32.8)			
—26.9	11	26.4	27.5	28.5	29.4	30.4	31.0	31.8						
·	6	27.7	29.1	30.4	(31.8	32.3	32.7)							

B. *INSIDE KAVIRONDO GULF*

entimetre of Body ,ength at st Breeding	No. of Fish	Body Length at Ring Number 1	2	3	4	5	6	7	8	9	10	11	12	13
—20.9	12	20.6	23.2	25.0	26.6	27.2	28.0	28.3	29.2	(29.0				
—21.9	20	21.6	23.8	25.4	26.6	27.6	28.2	29.0	29.6	30.1				
—22.9	29	22.4	24.9	26.5	27.5	28.3	29.2	(28.1	28.9)					
—23.9	40	23.4	25.4	27.1	28.1	29.0	29.7	30.0						
—24.9	24	24.4	26.4	27.8	28.7	29.3	29.9							
—25.9	29	25.3	26.9	28.1	29.0	29.7	30.5	(32.3)						
—26.9	4	26.2	27.8	29.0	30.1	(31.1	31.8	32.4)						
>	4	27.6	29.5	30.3	31.3	32.1	32.9							

C. *OUTSIDE KAVIRONDO GULF AND MWANZA AREA*

Area	No. of Fish	Body Length at Ring Number 1	2	3	4	5	6	7	8	9	10
Outside irondo Gulf	46	23.5	26.3	28.1	29.4	30.4	31.2	31.9	32.4	32.8	34.0
Mwanza	65	24.2	26.5	28.0	29.0	29.9	30.4	31.4			

TABLE III

The average growth between successive rings, of fish grouped according to the season of first breeding.

A. *JINJA*

Ring Group	No. of Fish	Length at maturation	Growth between rings 1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Aggregate No. of Fish	Percentage of Total
2	30	24.3	2.0								30	10
3	58	24.1	1.8	1.5							88	31
4	71	23.9	1.5	1.3	1.2						159	56
5	52	23.3	1.8	1.6	1.0	0.9					211	75
6	25	22.5	1.6	1.2	1.0	0.8	0.9				236	84
7	20	23.0	1.6	1.3	1.1	0.8	0.8	0.7			256	91
8	13	21.6	1.6	1.2	1.1	0.8	0.8	0.6			269	96
9	3	21.2)									272	97
10	6	)	Sample not adequate								278	99
11	2	)									280	100

B. *INSIDE KAVIRONDO GULF*

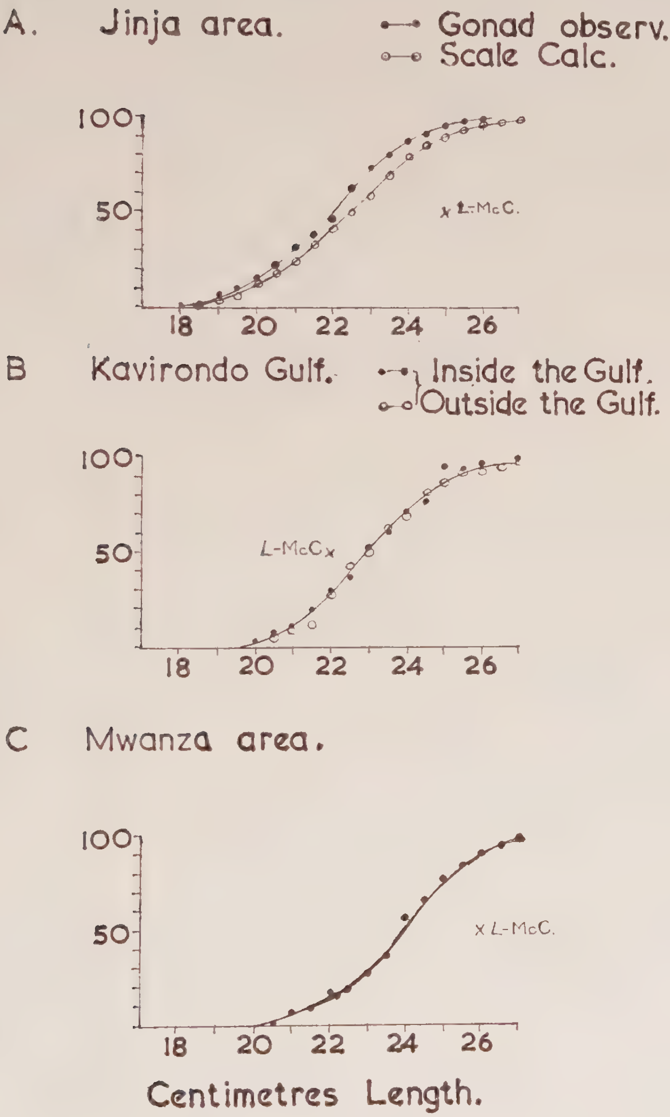
Ring Group	No. of Fish	Length at maturation	Growth between rings 1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Aggregate No. of Fish	Percentage of Total
2	13	23.1	2.4								13	8
3	32	23.6	2.0	1.6							45	27
4	42	23.4	2.0	1.7	1.2						87	53
5	34	23.0	2.0	1.3	1.2	1.0					121	74
6	23	22.6	2.2	1.5	1.2	1.0	0.8				144	88
7	10	23.3	1.9	1.4	1.2	0.9	0.9	0.7			154	94
8	4	23.5	2.1	1.5	1.2	1.0	0.9	0.8	0.9		158	97
9	4	20.5	1.7	0.9	1.5	0.9	1.0	0.8	0.8	0.7	162	100

ported by the data shown in Graph IIIA. There is a close correspondence between the percentage distribution of immature fish observed in the catches of the critical length groups and the calculated distribution of the lengths at first breeding of the same groups.

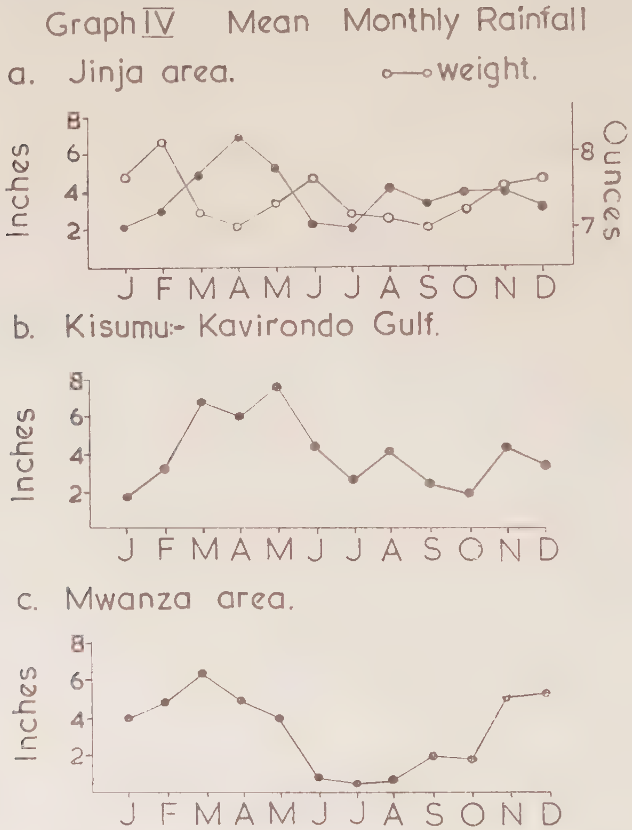
Holden (op. cit.) has correlated ring formation with breeding activity in *T. esculenta* and *T. variabilis*. It is interesting to note that whereas juvenile *T. esculenta* may lay down scale rings, this has not been observed in *T. variabilis* as would be expected if the rings were caused by environmental influence. The succession of broods within a single breeding period prevents a rigid statistical relation between the sexual state of the gonad and the formation of a ring on the edge of the scale.

The seasonal fluctuations in the weight of *T. esculenta* 20—24 cm. (i.e. immature or first breeding fish that were caught in gill nets)

Graph III. The Distribution of Length at Maturation.



show clearly that the weight increases during the period December to February, and in June. This is illustrated in Graph IV, together with the seasonal rainfall in the Jinja area where the fish were caught. The increased weight occurs during the dry seasons when the fish are not breeding.



This evidence suggests that during periods of breeding activity the growth of *T. esculenta* is (at least partially) arrested resulting in the formation of a ring on the scales which becomes apparent when growth is renewed.

Lowe-McConnell (op. cit.) observed that the proportion of breeding fish in the catches increases during the rainy seasons. Graph IV shows the distribution of the rainfall in the areas from which the samples of fish, used in this work, were collected. The annual rainfall figures in the Jinja area and in the Kavirondo Gulf area are bimodal, whereas those from the southern areas of Lake Victoria form a unimodal curve. While there are peak periods of

gonad activity at these times, a certain number of breeding fish can be observed at all times of the year. Hence there is no clear evidence as to the number of breeding periods that any one individual may undergo in each year. It is suggested that, although the exact time of breeding may vary slightly, any one fish undergoes a period of breeding activity during the rainy periods and that during such a period, which is responsible for the formation of a scale ring, several broods may be spawned. Observations on the female gonads have shown that up to three batches of ova may be maturing in the gonad at the same time. Evidence from a fish which was marked when 'recently spent' and recaptured when 'brooding' has suggested that approximately seven to eight weeks may elapse between broods. The spawning of three broods would therefore cover a period of four months. If two such periods occur annually in the Jinja area then they would be separated by resting periods of two months. This conclusion is not inconsistent with the observations and since a finite number of breeding periods must occur in each year it is most reasonable to suppose that they could not be more than biannual in any one fish at the northern end of the lake.

The data on the ring formation on the scales of fish from the Jinja area have thus been analysed on the assumption that two rings are laid down in each year, although this does not presuppose that they breed at exactly the same time each year.

At the southern end of the lake there is one main rainy season. The seasons are more clearly defined and, similarly, there appears to be a more clearly defined single breeding period. The data from this area have therefore been analysed on the assumption of a single ring in each year. This assumption was also made for the sample from outside the Kavirondo Gulf since this was collected from the eastern coast of Lake Victoria where the rainfall is also unimodal, although the exact time of the rains does not coincide with that of the areas further south.

The Kavirondo Gulf itself is at the north eastern tip of the lake where the rainfall and the peak periods of gonad activity are annually bimodal: data from this area have therefore been treated in the same way as for the Jinja area. It has been assumed that the fish do not undergo extensive migrations from the northern to southern areas, or vice versa. There is some evidence that the populations of *T. esculenta* are localised (GARROD, 1957) and the returns of marked fish support this. Only one recaptured fish has covered a very long distance while a large proportion of the total recaptured were taken within a few miles of the point of release. Recently a fish that had been free for three years was recaptured within three miles of the point of release although it may have covered considerable distances prior to its

recapture. The possibility of individuals changing their breeding frequency as a result of migration has been ignored since there is no indication on the scales that this may have occurred.

On the hypothesis discussed above, that the rings on the scales of *T. esculenta* are associated with breeding and that a certain number of such periods occur in each year, the data in Table II can be interpreted by VON BERTALANFFY's equation of growth (BEVERTON & HOLT, 1957). In this work, growth is described by an exponential function where

$$L_t = L_\infty \left(1 - e^{-K(t - t_0)}\right)$$

L_t = the length at a given time,
L_∞ = the asymptotic length towards which the fish is growing,
K = a constant defining the deceleration of the specific growth rate, and
t_0 = the theoretical point of birth where the mathematical curve of growth cuts the time axis.

This formula may also be written to express the relation between the lengths of a fish at the beginning and end of any period of duration 't', viz.:

$$L_{t+1} = L_\infty \left(1 - e^{-Kt}\right) + L_t e^{-Kt}$$

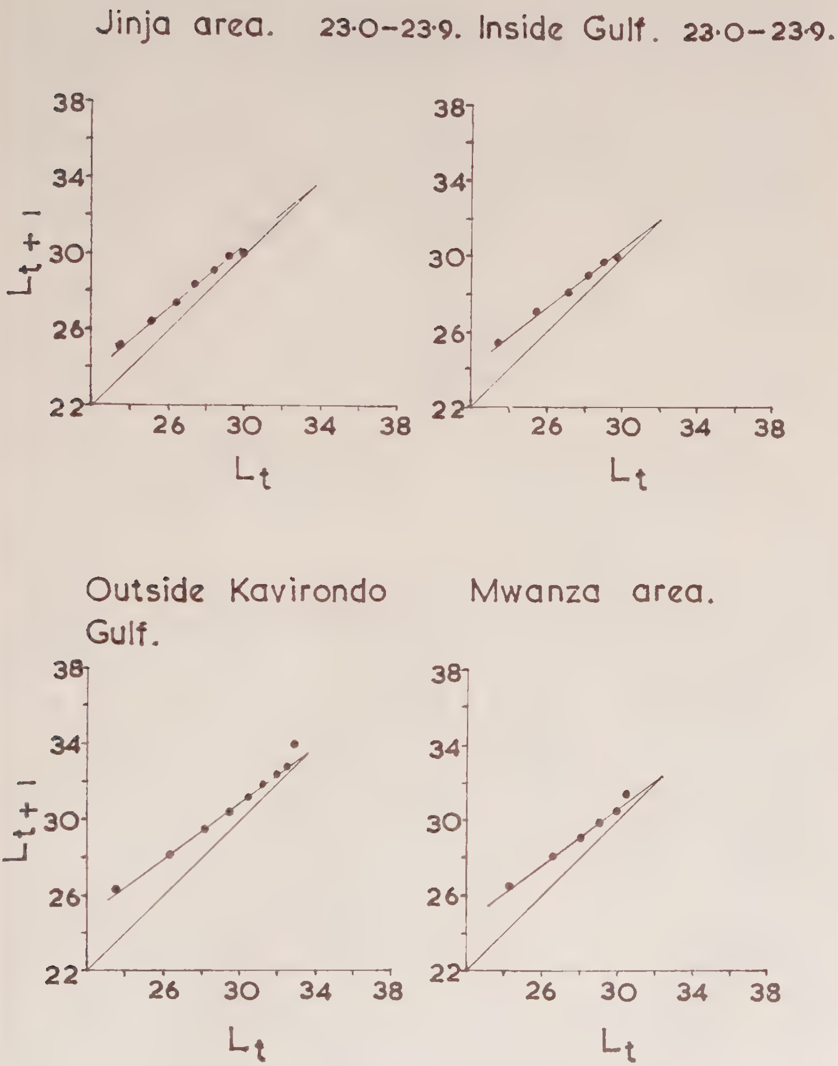
The formula has been successfully applied to growth data for many species. If data can be fitted to this formula the plot L_{t+1} against L_t will be a straight line of a slope e^{-Kt} from which K can be calculated, and with an intersect on the line $L_{t+1} = L_t$ (i.e. the bisector through the origin) which is the asymptotic length towards

TABLE IV

The Parameters K and L_∞ Calculated for Fish from the Jinja area and from within the Kavirondo Gulf.

First Breeding Size	*Jinja Area*			*Inside the Kavirondo Gulf*		
	K	L_∞	%	K	L_∞	%
19.0—19.9	0.44	31.0	4.3			
20.0—20.9	0.44	31.4	13.3	0.63	31.0	7.4
21.0—21.9	0.40	32.0	15.4	0.47	32.4	12.4
22.0—22.9	0.32	35.0	16.8	0.70	32.4	17.9
23.0—23.9	0.32	33.8	19.7	0.50	32.0	24.8
24.0—24.9	0.63	31.3	16.5	0.71	31.5	14.8
25.0—25.9	0.26	38.0	7.8	0.44	33.9	17.9
26.0—26.9	0.19	39.1	6.0	0.50	35.7	2.5
27.0				0.46	34.8	2.5

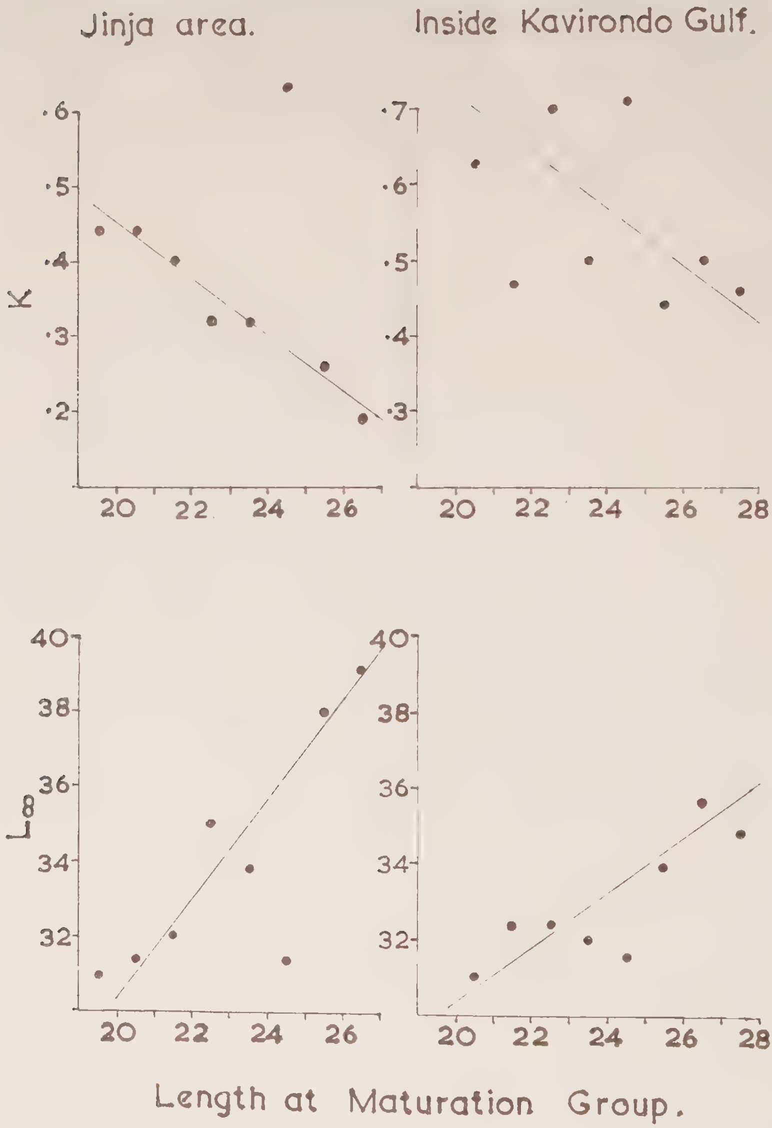
Graph V. The Plot of L_{t+1} Against L_t.



which the fish is growing. An example of the fit of the data in Table II to this formula is shown in Graph V. The parameters calculated in this way from the data in Table II are shown above in Table IV.

The figures in Table IV were calculated from the plots of L_{t+1} against L_t that were fitted by eye since the unequal spacing of the points makes it difficult to obtain a satisfactory fit by the least

Graph VI The Distribution of K and L_∞.



squares method. Furthermore the figures given are the result of the first fit since this method is particularly sensitive to small variations in the slope of the line L_{t+1} against L_t. The samples from within the Jinja area and from within the Kavirondo Gulf are normally distributed about the modal length at first breeding, 23.0 cm., and in later calculation of the growth curve the figures for this group have been taken as representative of the area. The distribution of the other samples were not normal since the number of fish used were small; for this reason these samples have not been sub-divided. The parameters calculated from the data for these two areas are shown in Table V.

TABLE V

The Parameters K and L_∞ calculated for Fish from outside the Kavirondo Gulf and from the Mwanza Area.

Area	K.	L_∞
Outside the Kavirondo Gulf	0.31	33.5
Mwanza Area	0.31	32.4

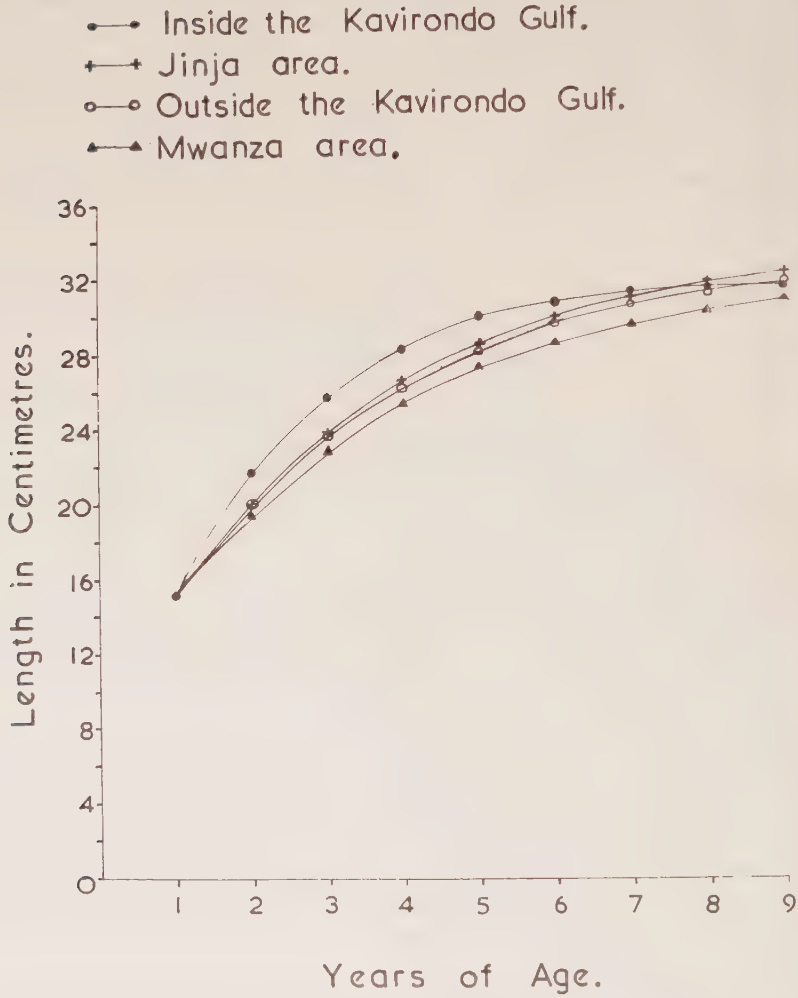
(It must be remembered that these figures are based on the assumption of one ring annually)

Graph VI illustrates the data shown in Table IV; it is clear that there are simultaneous trends in the magnitude of K and L_∞. At present the data are not adequate to define the relationship rigorously.

The calculation of the growth curves from these data require a third parameter t_0. In order to compute this value it is necessary to know any one given length at age. In this work the only available data suggest a modal growth rate of fifteen centimetres in the first year in all areas of the lake: these data are discussed in the introduction to this study. Since the data represent a modal growth rate they may only be used to calculate the parameter t_0 for the modal groups of length at first breeding for the samples from the Jinja and Kavirondo Gulf areas. However, for the sake of the comparison, and in the absence of more accurate data, the estimate of growth for the first year has also been used to calculate growth curves for the complete sample from outside the Kavirondo Gulf and from the Mwanza area. The plot L_{t+1} against L_t for these four groups are shown in Graph V, and the calculation of the parameter t_0, and of the growth curve for the modal group of length at first breeding in the Jinja area are shown in Appendices I and II.

A second estimate of the growth of *T. esculenta* in the first year can be obtained by extrapolating the plot of L_{t+1} against L_t to the

Graph VII. Calculated Growth Curves of Tilapia esculenta.



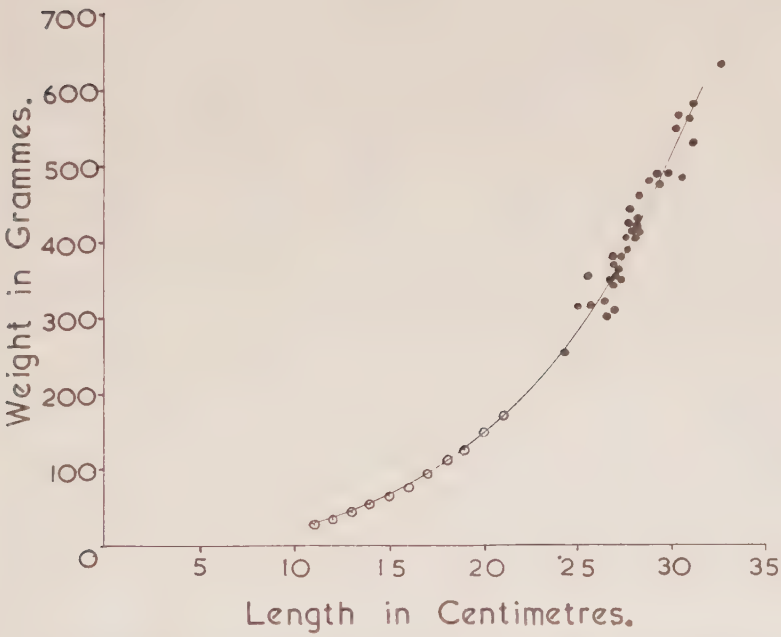
point where it cuts the 'y' axis (Frost & Kipling, personal communication). This plot of the theoretical growth curve (Appendix II) suggests that the length after one year is 9 cm. and that the observed mode at 15 cm is in fact two years growth. Furthermore using 9 cm. as $t = 1$ gives an estimate of t_0 of $+ 0.2$ which is closer to zero than the estimate where the value $t_1 = 15$. If this is true the data outlined in the introduction must be reinterpreted but a solution does not immediately present itself: also the value of K may decline during life

(see below) and there is no reason to expect an exact fit of the data from the point of hatching. Until further evidence is available the problem of the period of juvenile growth cannot be decided but in any event the conclusion has no bearing on the use of breeding rings as age indicators, the time scale of the growth would merely be increased by one year throughout.

The growth curves obtained in this way are shown in Graph VII.

Graph VIII. The Length Weight Relationship, 23.0–23.9cms. group.

o–o after Lowe–McConnell.

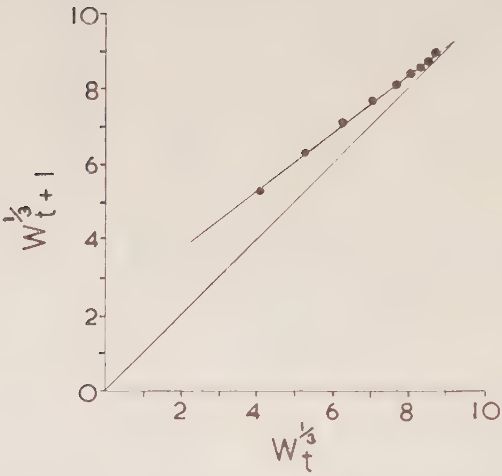


The scale data were not analysed for the growth in weight of the fish but, using the length/weight relationship shown in Graph VIII, the length at age calculations were transformed and treated in a similar manner using a modification of the Von Bertalanffy formula:

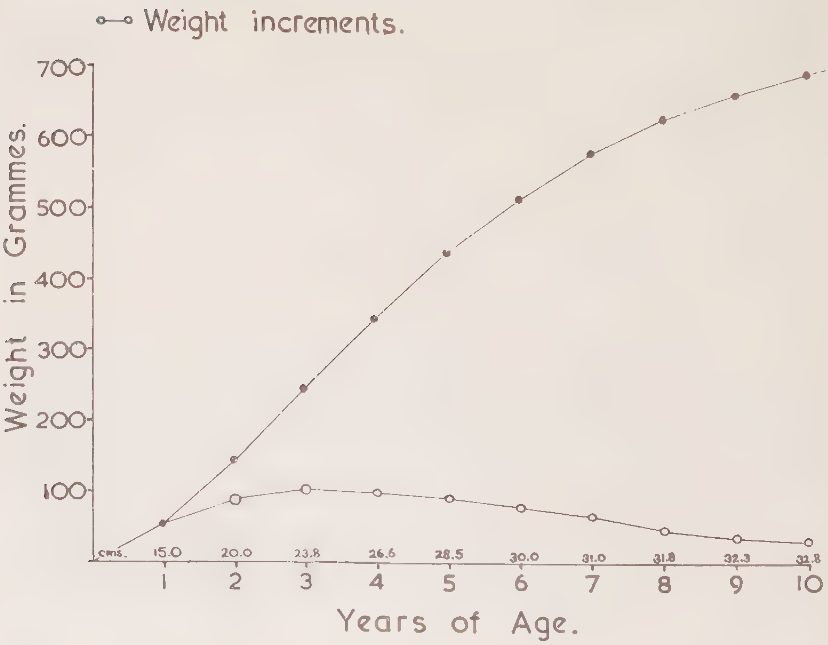
$$W_t = W_\infty \left(1 - e^{-K(t - t_0)}\right)^3$$

where the parameters K and W_∞ can be calculated from the plot of $W_t^{\frac{1}{3}} + 1$ against $W_t^{\frac{1}{3}}$. This is shown for fish from the Jinja area in Graph IXA. From the parameters obtained the curve of growth in

Graph IXa The Plot of $W_{t+1}^{1/3}$ against $W_t^{1/3}$.



Graph IXb The Calculated Curve of Growth in Weight; Jinja area, 23.0–23.9cms group.



weight was calculated as before and is shown in Graph IXB together with the variation of the weight increments. It should be noted that the inflexion of the curve of the growth in weight occurs at a length corresponding approximately to the onset of breeding as might be expected, and that over the size range exploited by the commercial fishermen, (26—33 cm) the growth in weight is almost linear.

THE VALIDITY OF THE GROWTH CURVES

The interpretation of the scale rings is based on the hypothesis that a certain number are laid down in each year and that this number is constant although the actual time of breeding may vary. That the plot L_{t-1} against L_t is a straight line, as required by the growth formula, is in itself a substantiation of the assumption. In the absence of other growth indicators the only check on the validity of the interpretation is to compare the growth estimates so obtained with other independent estimates reviewed in the introduction.

1) Marking experiments carried out by the Lake Victoria Fisheries Service have given unreliable results. Of the fish marked only fifty three showed appreciable growth; of these fourteen grew more rapidly than predicted by the growth curve, eighteen showed accurate correspondence and the remaining twenty one showed less growth. Unsatisfactory as it is, these results give some indication of being equally distributed about the growth curve which is based upon the data for the modal size at first breeding.

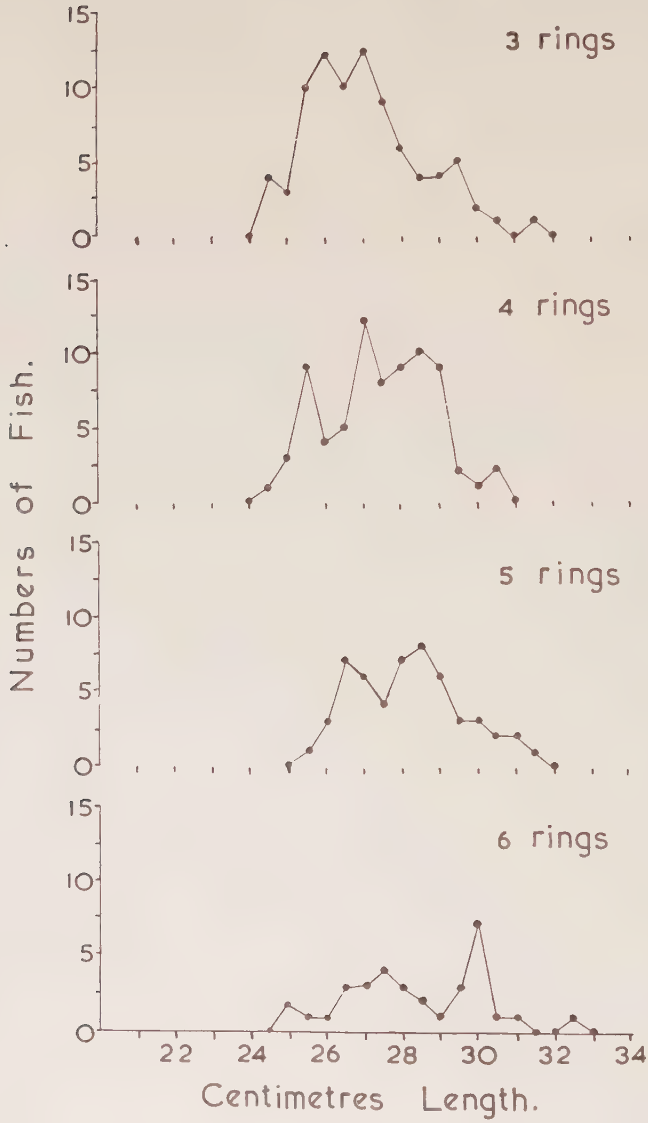
2) The length frequency distributions of fish in successive ring groups, i.e. all fish with one ring, two rings etc., suggest a growth of 26—29 cms in two years in the Jinja area. This agrees with the growth predicted by the calculated growth curve for this area. The data are shown in Graph X. It will be noted that only fish with three to six rings have been included owing to the method of sampling: the earlier ring groups are not fully represented because early maturing fish with only two rings would not have been caught in the gear used; conversely late maturing fish are not fully represented in the upper ring groups since the possibility of their survival to this age is not high (see Table III). Inspection of Table II shows that all maturation groups are represented in the third to sixth ring groups.

Data from other areas show similar agreement with the predicted growth.

3) Lowe-McConnell's observations upon the growth of mature *T. esculenta* in Tanganyika waters do not correspond with the calculated growth pattern although the rate of growth is of the same order.

4) It is interesting to note that this rate of growth of *T. esculenta*

Graph X The Length Frequency Distributions of Ring Groups.



corresponds well with that of *T. squamipinnis* and *T. lidole* which occupy a similar ecological niche in Lake Nyasa (LOWE, 1952). The growth rate of *T. esculenta* is also comparable to that of *T. nilotica* from the Noussa Hydrodrome, Egypt, (JENSEN 1957). This species is also ecologically comparable to *T. esculenta.*

DISCUSSION

The purpose of treating the scale data in the above manner is that at present the growth of fish can only be incorporated into yield equations and other methods of the analysis of the population dynamics in terms of the parameters K and L_∞ or W_∞, which, in the simplest form of analysis, are regarded as constant.

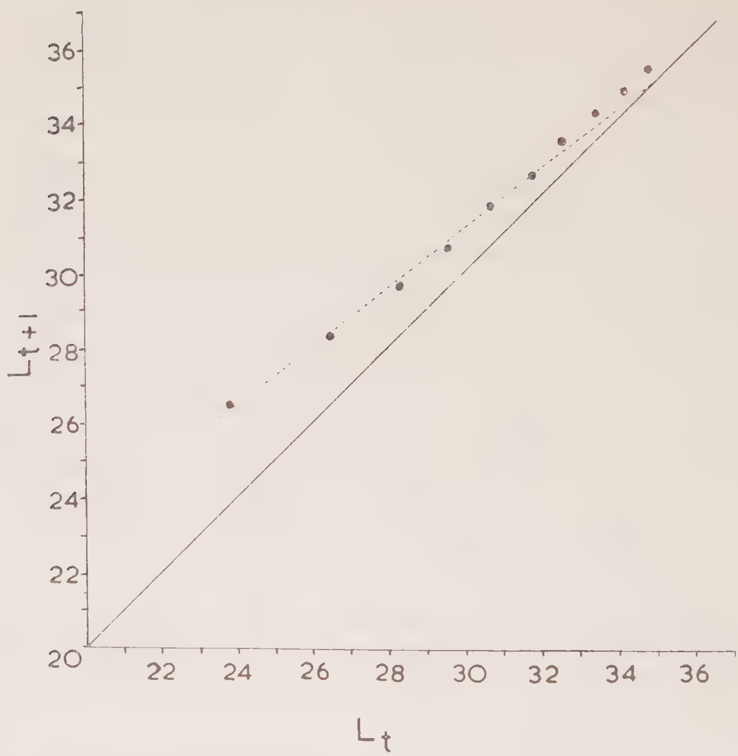
The growth curves shown in Graph VII were calculated from parameters based upon the first five years of the mature life history, and assuming that they remain constant throughout life. This is not strictly accurate since it is necessary to calculate t_0 to compensate for a slightly higher value of K in the juveniles. However it is possible that the magnitude of K will continue to decline throughout the life history. The numbers of very old fish available during this investigation were not adequate for a detailed examination of the phase of the life cycle from approximately eight years onwards, indeed the only source of 'older' fish appears to be outside the Kavirondo Gulf. The small number of fish with many rings obtained from this area, gave the plot of L_{t+1} against L_t which is shown in Graph XI. This is clearly nonlinear and predicts a sustained growth rate later in life. It appears that in this species the magnitude of K declines throughout life and it is not therefore valid to extrapolate the growth curve of infinity. However, Table III shows that at the present level of exploitation of this species, the chances of an individual surviving to an age where this growth may become significant, are not high. In further analyses the value of K for an individual in the exploited phase of the life history may be regarded as being constant, as shown by the fit of a straight line to the data in Table II and illustrated in Graph V.

It was also noted that there are trends in the value of K within the population, according to the length at maturation of the fish. For the purpose of population analyses these also may be disregarded since the populations appear to be normally distributed about a modal length at first breeding. This means that within a population an average value of K may be safely taken as a first approximation. However, the populations of *T. esculenta* in Lake Victoria appear to be localised and Graph VI shows that the range of the values of K

in the Jinja and within the Kavirondo Gulf areas are different. This must be taken into account in further work.

The trends in the value of the asymptotic length are more significant owing to the method of exploitation of the population. The most widely used commercial fishing gear is the gill net, which is highly

Graph XI The Plot of L_{t+1} Against L_t for Fish with Eleven Rings, Outside the Kavirondo Gulf.



selective. It is known that the asymptotic lengths of the smaller maturing groups fall within the selection range of the gear such that, following recruitment to the exploited phase of the population, a proportion of the fish will be exploited throughout the remainder of the life history, whereas others will eventually grow out of the

selection range of the gear used. This point is discussed more fully by BEVERTON (in press).

Variations of the values of K and L_∞ will provide a satisfactory expression of 'giantism' in *T. esculenta*. Unusually large individuals of up to 50 cm. length are recorded sporadically in the south western corner of Lake Victoria, in the Emin Pasha Gulf area. Scales from a number of these fish have been examined. They were not virgin fish, as had been supposed, nor were they excessively old; rather they appear to be fish that grow rapidly (compared with *T. esculenta* from other areas) having low K values and high asymptotic lengths. It can be seen from Table IV that fish of this type occur as the late maturing groups in both Jinja and Kavirondo Gulf samples. It is suggested that they represent the extreme of the range of variation of the two parameters which is found in only a small proportion of the population. In most areas of the lake the chances of a fish surviving to achieve this growth potential are not high, but in the Emin Pasha Gulf area the level of exploitation is relatively low and it is in that area that the giant fish are to be expected.

Since at present it is not possible to define rigourously the relationship between K and L_∞ it can only be concluded that it is inverse and that fish with high K values and low asymptotic lengths mature at a smaller size. A further relationship must exist between this feature and the age at which maturation occurs. This point cannot be investigated further until accurate methods of ageing juveniles have been developed, although a trend of earlier maturation at a smaller size with increasing K and decreasing asymptotic lengths is supported by the data from introduced fish populations in reservoirs referred to in the introduction. Experimental populations have been set up which may further this aspect of the investigation (CRIDLAND, unpublished).

As well as providing a mathematical tool for further analyses, the parameters K and L_∞ provide a means of comparing the characteristics of different populations. Reference to Graph VI shows that although the slope of the variation of K with the size at maturation may be the same in both the Jinja area and within the Kavirondo Gulf, the average value of K in the Jinja area is lower: this difference is statistically significant. The effect of this is shown in Graph VII; although the fish in both areas are growing to approximately the same asymptotic lengths, fish in the Kavirondo Gulf area will enter the exploited phase of the population (the length at recruitment to the exploited stock is about 26 cms) almost a year earlier than those in the Jinja area.

Analysis of the samples from outside the Kavirondo Gulf and from the Mwanza area are less reliable owing to the smallness of the

samples and because the former was selected in order to obtain fish with potentially the greatest number of rings. The parameters K and L_∞ calculated from these data are shown in Table V and can be seen to be comparable to those of fish from the Jinja area with the difference that the calculations are based upon the assumption of only one ring per year, for reasons that were discussed earlier.

Since the breeding frequency is lower it might be expected that the growth rate would be higher than at the northern end of the lake. This is not necessarily so; it may be that within the single breeding period more broods are produced; furthermore there is no evidence that phytoplankton is more abundant at the southern end of the lake and in any event these areas are less heavily exploited such that density dependent factors would tend to reduce the rate of growth to less than that of fish in northern waters of the lake.

The interpretation put forward here thus suggests that in the areas sampled the growth rate of *T. esculenta* is comparable, excluding the area within the Kavirondo Gulf, which is almost landlocked, where the growth rate is more rapid. This is more reasonable than the alternative, that in the southern areas the growth rate is much faster (as would be the case if two rings are laid down annually), for it would then be necessary to postulate that the formation of the scale rings is controlled by some factor other than breeding or seasonal environmental fluctuations which are in effect almost synonymous since the breeding activity is related to the annual rainfall.

Several further points of interest arose during the analysis which may be briefly enumerated.

1) The length at which maturation occurs, based upon the calculated length at which the first breeding ring was laid down, is approximately constant in each area sampled. These figures differ from those obtained by LOWE-MCCONNELL, by observation of the percentage of mature fish in the catches of the critical centimetre length groups. Data are shown in Table VI.

During this work the distribution of calculated lengths at first breeding were shown to correspond closely with the observed

TABLE VI

The Maturation Length of T. esculenta in the Sampled Areas of Lake Victoria.

Area	I 50% Calculated length at first breeding	II Observed length where 50% mature
Jinja area	22.5	25.0
Inside Kavirondo Gulf	23.0	22.0
Mwanza area	23.8	26.0

distribution of mature and immature fish in the catches (Graph III). The discrepancy between these figures (in Column I above) and LOWE-MCCONNELL's observations (Column II) may be due to a real change in the maturation length of the fish as a result of changes in the density of the population owing to fishing operations in recent years. A second explanation is the possibility of sampling bias. This is believed not to have occurred in the two large samples used in this study since the size at first breeding is normally distributed. It is also possible that in the Mwanza area complete regression of the gonad occurs between breeding periods which might be sufficient for confusion to occur between the immature fish and those that have only bred once.

The age at which maturation occurs can only be deduced from the growth curves. For the length at maturation groups figured these suggest that breeding first occurs at between two and three years of age in all areas of the lake.

2) Table III shows that the growth of fish that bred initially in the same season has been comparable during the past four years. Such variations that appear to have occurred are attributable to the method of sampling. (See Validity of Curves 2).

3) There is no significant difference in the growth rates of mature male and female fish. Both sexes are fully grown at approximately ten years of age although there are no data on the potential life span of the species. The greatest observed number of rings on the scales of any one fish was fifteen in a 'giant' from the Emin Pasha Gulf area. This would represent an age of probably a little over ten years.

SUMMARY

The scales of *T. esculenta* bear a series of clearly defined rings.

These rings may be interpreted as growth indicators of the hypothesis that they are laid down as a result of breeding activity. The evidence supporting this hypothesis is discussed.

In this form the data can be fitted to Von Bertalanffy's equation of growth. This itself supports the contention that the rings are laid down regularly, although in practice this is obscured by the fact that some breeding fish are to be found throughout the year.

Defining the growth rate of this species in terms of the parameters K and L_∞ it has been shown that K, the rate of deceleration of the specific growth rate, may itself decline throughout the life of an individual. There are simultaneous trends in the magnitude of these parameters; as the length at which maturation occurs increases, the value of K decreases and is at the same time inversely related to the asymptotic

length of the fish. It is also probable, in view of the maturation of artificial populations, that these variations are also related to the age of maturation. This is being investigated further. The above variations occur within a population but comparison of the data from different areas of Lake Victoria shows that there are significant differences in the order of magnitude of K in the different areas, although the values of L_∞ are comparable.

In this form the parameters may be incorporated into further analyses of the population dynamics of the species.

Comparison of the different areas sampled shows that the value of K of fish within the Kavirondo Gulf is significantly higher than elsewhere in the lake.

The variation in the parameters defining the growth provides an explanation of the occurrence of 'giant' fish in the Emin Pasha Gulf area.

Fish are fully grown at approximately ten years of age but at the present time the level of exploitation of the stock is such that in the northern areas of Lake Victoria very few fish survive more than four years in the exploited phase.

Owing to the possible variation of the time of breeding within any one year, these data cannot be used for the detailed analysis of the growth of any one individual; at present it is not possible to age the fish from the time of hatching.

ACKNOWLEDGEMENTS

I would like to thank Mr. R. J. H. Beverton of the Fisheries Laboratory, Lowestoft, for his advice on many aspects of the interpretation put forward and also to thank Dr. W. E. Frost and Miss Kipling of the Freshwater Biological Association Laboratory for their criticism of the manuscript. My thanks are also due to Messrs. 'Lake Fish Distributors Limited', of Kisumu, for permission to sample their fish catches and to the Officers of the Lake Victoria Fishery Service for their assistance in the collection of samples. I would also like to thank the Director and my colleagues of E.A.F. R.O. for many helpful discussions during this work.

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APPENDIX I

Calculation of t_0 for fish from the Jinja area.

$$Lt = L_\infty (1 - e^{-Kt})$$

$$1 - e^{-Kt} = \frac{Lt}{L_\infty}$$

$$1 - e^{-.32t} = \frac{15}{33.8}$$

$$e^{-.32t} = 1 - \frac{15}{33.8}$$

$$e^{-.32t} = 0.56$$

$$t = \frac{1}{.32} \log_e .56$$

$$= \frac{.58}{.32}$$

$$= -1.8$$

But t = 1 year $\therefore$ $t_0 = -0.8$

APPENDIX II

Calculation of the Growth Curve for Fish from the Jinja area.

t.	$t_1 - t_0$	Kt	e^{-Kt}	$1 - e^{-Kt}$	$L_\infty (1 - e^{-Kt})$
1	1.8	0.58	.560	.440	15.0
2	2.8	0.90	.407	.593	20.0
3	3.8	1.22	.295	.705	23.8
4	4.8	1.54	.214	.786	26.6
5	5.8	1.86	.156	.844	28.5
6	6.8	2.18	.113	.887	30.0
7	7.8	2.50	.082	.918	31.0
8	8.8	2.82	0.60	.940	31.8
9	9.8	3.14	.043	.957	32.3
10	10.8	3.46	.031	.969	32.8

$K = .32 \quad L_\infty = 33.8$

Difflugia? marina Bailey, une espèce oubliée, synonyme de Quadrulella symmetrica (Wallich), Rhizopode testacé d'eau douce.

Remarques sur la systématique des Nebelidae

Par

GEORGES DEFLANDRE & MARTHE DEFLANDRE-RIGAUD

INTRODUCTION

L'élaboration d'un fichier des Radiolaires fossiles et actuels, dans le cadre du Fichier micropaléontologique que nous avons entrepris en 1943, conduit à revoir des travaux anciens, souvent oubliés ou méconnus par les auteurs modernes. Mis de côté leur intérêt purement historique, on y trouve parfois des indications inattendues, susceptibles comme c'est le cas ici, de poser des problèmes taxinomiques.

Dans un travail consacré aux „formes microscopiques trouvées dans un sondage de la mer de Kamtchatka", BAILEY, en 1856, décrit un certain nombre d'espèces nouvelles de Diatomées, Polycystines, Rhizopodes etc., parmi lesquelles figure une *Difflugia*? *marina* B. qui n'est autre que le Thécamoebien d'eau douce ,classiquement connu sous le nom de *Quadrulella symmetrica*, placé par l'un de nous (G. DEFLANDRE, 1936) dans le genre *Nebela* TARANEK.

Aucune des listes synonymiques publiées jusqu'à présent pour *Nebela (Quadrulella) symmetrica* (WALLICH) ne comporte *Difflugia*? *marina* BAILEY. Et c'est fort heureux car, si LEIDY, en 1879, avait mentionné ce nom dans la liste qu'il donne page 142, et qui, pratiquement, a été recopiée par tous ses successeurs, il ne fait nul doute que l'application des Règles de la priorité aurait incité l'un d'eux à appeler l'espèce en question *Quadrula marina* (BAILEY) SCHULZE 1875, puis *Quadrulella marina* (BAILEY) COCKERELL 1911, et enfin *Nebela (Quadrulella) marina* (BAILEY) sec. DEFLANDRE 1936; On

conviendra qu'il serait pour le moins regrettable de devoir utiliser le nom de *marina* pour un Thécamoebien cosmopolite d'eau douce et il est bon que les Règles actuelles permettent de rejeter définitivement l'épithète spécifique „*marina*" BAILEY, qui n'a pas été utilisée depuis plus de cent ans.

Il n'est pas sans intérêt de donner la raison — accidentelle — de l'omission de LEIDY dans la liste synonymique en question. LEIDY a connu le travail de BAILEY et l'a mentionné dans sa bibliographie critique, p. 299, signalant alors: *Difflugia*? *marina* fig. 7: A large marine form, $2^1/_4$ mm long by $1\ ^1/_4$ mm wide, with structure of *Quadrula*.

Les dimensions énormes qu'il indique (plus de deux millimètres de long) n'ont évoqué pour lui aucun rapport possible avec *Quadrula symmetrica*, qu'il connaissait bien, et à qui il attribue une longueur de 80 à 140 μ. En réalité BAILEY avait donné pour dimensions à sa *Difflugia*? *marina* $2^1/_4$ m sur $1\ ^1/_4$ m, précisant dans son texte (page 2, seconde note infrapaginale) qu'il utilisait l'unité m, égale à un millième de pouce anglais, soit 25 μ. Ainsi, la coquille figurée mesurait donc environ 56 μ de long sur 31 μ de large ce qui, compte tenu de l'imprécision relative des mesures à l'époque, correspond à peu près aux plus petites formes connues de *Nebela (Quadrulella) symmetrica*. Nous avons d'ailleurs pu constater que les mesures données par BAILEY sont, dans l'ensemble, nettement inférieures à la réalité.

REMARQUES SUR LA SYSTÉMATIQUE DES NEBELIDAE.

Examinons, maintenant, l'attribution générique de l'espèce *symmetrica* (WALLICH). En faisant remarquer la logique du classement des espèces revêtues de plaques quadrangulaires siliceuses dans le genre *Nebela* (idée émise par WAILES dès 1918, après qu'il eut lui-même décrit deux espèces de *Nebela* américaines, à plaquettes carrées endogènes), G. DEFLANDRE, en 1936, écrivait „*Quadrula symmetrica* devenue *Quadrulella symmetrica* s'appellera donc *Nebela (Quadrulella) symmetrica* . . . mais je crois bien qu'on la verra encore figurer longtemps dans les ouvrages d'enseignement sous son nom original, et le mal ne sera pas bien grand". En 1953, toutefois, il a conservé au genre *Nebela* un sens large, incluant *Quadrulella*.

Il est évident que, si l'on veut restreindre l'acception du genre *Nebela* TARANEK, sans aller toutefois jusqu'à le découper en treize genres *(Physochila, Argynnia, Deflandria, Quadrulella, Nebela, Schaudinnia, Alocodera, Apodera, Umbonaria, Pterygia, Leidyella, Porosia, Penardiella)* comme le fit abusivement W. JUNG en 1942, il y a lieu de retenir *Quadrulella*. C'est ce qu'a fait récemment TH.

Fig. 1 à 3. *Quadrulella symmetrica* (WALL.) COCK. 1, d'après BAILEY 1856, Planche fig. 7, sous le nom de *Difflugia*? *marina* B., sondage dans la mer d'Okhotsk; 2, d'après WALLICH 1863, Planche VIII, fig. 16, sous le nom de *Difflugia pyriformis*, var. *symmetrica* (Wall.) « montrant l'arrangement symétrique des plaques cristallines », mares de Hampstead, au nord de Londres; 3. d'après WALLICH 1864, Planche XVI, fig. 26, sous le nom de *D. symmetrica*, « montrant les plaques hyalines rectangulaires: c, forme de l'ouverture; b, un spécimen plus comprimé dans lequel l'ouverture est presque close; d, quelques plaques détachées »; même localité. Toutes ces figures sont fortement agrandies par rapport aux figures originales.

GROSPIETSCH dans un excellent petit ouvrage d'initiation, destiné d'abord aux étudiants et amateurs, auquel il ne manque vraiment qu'un petit index des genres et espèces, comportant les noms de leurs auteurs. G. DEFLANDRE, dans le Chapitre Rhizopoda and Actinopoda qu'il a rédigé pour la seconde édition d'un ouvrage américain de semi-vulgarisation sur la biologie des eaux douces (WARD & WHIPPEL, Freshwater Biology, 2d ed. by W. T. EDMONDSON, sous presse) a adopté, d'un point de vue didactique, la même solution, remarquant toutefois que *Quadrulella* pouvait être considéré comme un sous-genre de *Nebela*. Mais il a alors compris, dans le genre *Quadrulella*, toutes les espèces américaines à plaques quadrangulaires (dont les deux *Nebela* de WAILES, 1918) englobant donc les taxons ci-après:

Quadrulella symmetrica (WALLICH), avec les variétés *longicollis* TARANEK, *irregularis* PENARD, *curvata* WAILES;

Quadrulella tropica WAILES (*Nebela tropica* WAILES 1912)

Quadrulella quadrigera DEFLANDRE 1936;

Quadrulella scutellata WAILES (*Nebela scutellata* WAILES 1912 pro parte).

Les belles recherches de Madame L. GAUTHIER-LIÈVRE sur les Thécamoebiens d'Afrique, et particulièrement sa dernière contribution à la connaissance des *Nebela* sensu lato (1957) apportent de nouveaux arguments relativement à ce problème de systématique. En effet les descriptions et les excellents dessins qu'elle a donnés de toute une série d'espèces nouvelles démontrent qu'il existe des thèques à plaquettes carrées dont l'architecture générale correspond exactement à des espèces de *Nebela* sensu stricto à écailles arrondies. Les plus démontratives de ces formes sont *N. (Quad.) symmetrica* var. *tubulata* GAUTHIER-LIÈVRE, *N. (Quad.) subcarinata* GAUTHIER-LIÈVRE et *N. (Quad.) alata* GAUTHIER-LIÈVRE, qui sont respectivement des homologues à plaquettes quadrangulaires des espèces suivantes de *Nebela* sensu stricto: *Nebela Wailesi* DEFL., *Nebela galeata* PENARD (vel *N. carinata* LEIDY), *Nebela gracilis* PENARD.

Madame L. GAUTHIER-LIÈVRE a pertinemment relevé ce fait. Elle écrit: „Quoique de nombreux jalons manquent encore, les découvertes de formes variées de *Quadrulella* semblent indiquer que ce sous-genre a suivi une évolution phylogénétique parallèle à celle du sous-genre *Nebela*. La forme de base paraît être la *Quad. symmetrica* type dont la variété *longicollis* correspondrait à la *N. collaris* et la variété *tubulata* à *N. Wailesi* (ce qui serait un argument pour élever cette variété au rang spécifique). *Quad. elegans* et *N. Penardiana* ont des silhouettes identiques comme le fait remarquer DECLOÎTRE. Il en est de même pour *Quad. lageniformis* VAN OYE et *N. lageniformis*.

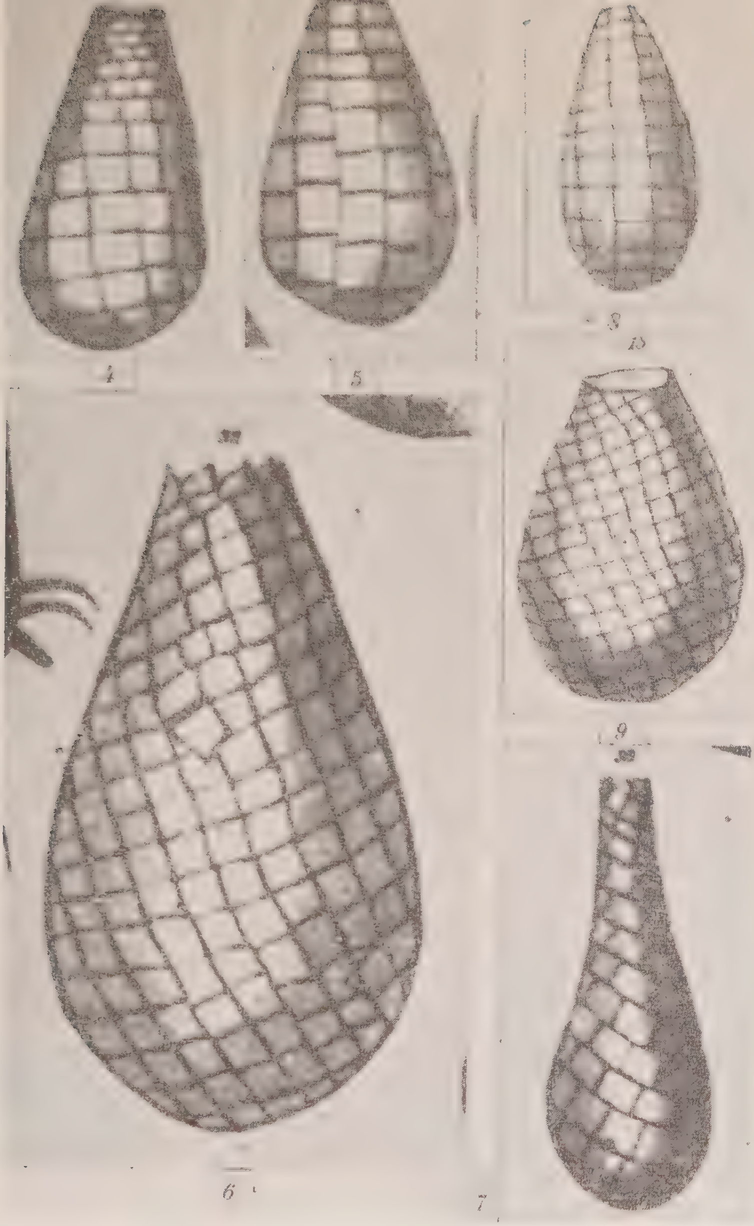

Fig. 4 à 9. *Quadrullela symmetrica* (WALL.) COCK. 4 et 5, d'après EHRENBERG 1871, Pl. II, fig. 4 et 5, sous le nom de *Difflugia assulata* EHR., 4: sur humus et mousses, Bischerre, Liban — 5: Guyane britannique, Sierra Roraima; 6, d'après EHRENBERG 1871, Pl. II, fig. 32, sous le nom de *Difflugia tessellata* EHR., du Cap de Bonne Espérance; 7, d'après EHRENBERG 1871, Pl. II, fig. 33, sous le nom de *Difflugia capensis* EHR., du Cap de Bonne Espérance (ces deux dernières formes proches des var. *irregularis* PEN. et *longicollis* TAR.); 8, d'après EHRENBERG 1871, Pl. III, fig. 14, sous le nom de *Difflugia carolinensis* EHR., d'Amérique du Nord: 9, d'après EHRENBERG 1871, Pl. III, fig. 15, sous le nom de *Difflugia leptolepis* EHR., d'Amérique du Sud. Toutes ces figures sont fortement agrandies par rapport aux figures originales.

Quadrulella subcarinata et *Quad. alata* dérivant probablement de formes à fond ogival seraient les homologues de *N. galeata* et *N. gracilis*."

Quelle conclusion tirer de ces remarques?

Si l'on admet une évolution phylogénétique parallèle des deux sous-genres *Quadrulella* et *Nebela*, ayant pour souches respectives les deux espèces *Quadrulella symmetrica* sens. lat. et *Nebela collaris* sens. lat., il est logique et désirable de ne les plus considérer comme des sous-genres, mais bien comme des genres distincts. Doit-on, alors, reconnaître aux espèces (ou à certaines espèces) du genre *Quadrulella* la faculté de secréter exceptionnellement des écailles rondes (cas de l'espèce *N. (Quad.) quadrigera* DEFL.) et à celles du genre *Nebela* celle de posséder exceptionnellement des plaquettes quadrangulaires (cas de *N. galeata* PENARD, dessinée par Mme GAUTHIER-LIÈVRE, loc. cit. fig. 14 B, et cas divers évoqués par G. DEFLANDRE, 1936, passim). Il ne semble pas que les *Quadrulella* utilisent normalement des écailles provenant de proies ingérées, d'origine animale ou végétale. Par contre les *Nebela*, très carnassières, peuvent fort bien réutiliser des plaquettes carrées de *Quadrulella* dévorées.

Abordant le problème sous un autre angle, on est amené à évoquer la possibilité pour une espèce donnée de conserver sa forme propre, son architecture générale tout en modifiant totalement la nature du revêtement: substitution de plaquettes quadrangulaires aux écailles rondes (ou vice-versa?). Cette hypothèse est peu vraisemblable, dans l'état actuel de nos connaissances. Celle du parallélisme dans l'évolution de lignées de *Quadrulella* et de *Nebela* s.s. répond mieux à nos conceptions modernes, mais une solution probante ne saurait être obtenue qu'expérimentalement.

Notons encore que P. VAN OYE, dans son dernier travail sur les Rhizopodes du Congo belge (1958) tend à redonner à *Quadrulella* la position hiérarchique d'un genre (loc. cit. p. 103). Cet auteur „attache une grande importance, d'un point de vue biogéographique, au pourcentage des différents genres" (in litteris 3.11.1958), et la réunion des espèces de *Quadrulella* et de *Nebela* sous la seule rubrique *Nebela* constitue donc, pour lui, une certaine gène, voire même un trouble quant aux considérations déductibles de certains tableaux de répartition.

L'ensemble des données et des arguments ci-dessus, d'une part, les tendances modernes de la systématique d'autre part conduisent malgré l'absence de preuves décisives, à abandonner la conception, pourtant si logique, d'un genre *Nebela* au sens large. Le sous-genre *Quadrulella* (in DEFLANDRE 1936) redevient le genre *Quadrulella* COCKERELL, et, en attendant une nouvelle révision du genre *Nebela*

TARANEK, le genre *Physochila* JUNG doit être adopté dès maintenant pour la Section I du sous-genre *Nebela* (G. DEFLANDRE, 1936, p. 228). Madame L. GAUTHIER-LIÈVRE, d'ailleurs, décrit une intéressante forme nouvelle (*Physochila batekensis* - *Nebela b.*), analogue à *Nebela caudata* LEIDY dont elle se distingue par les caractères du pseudostome, et à propos de laquelle pourrait être aussi invoqué un parallélisme évolutif.

HISTOIRE ET SYNONYMIE DE Q. SYMMETRICA.

A titre documentaire, nous reproduisons ici la figure de BAILEY de *Difflugia? marina*, qui se trouve donc être la première représentation connue de *Quadrulella symmetrica*, paradoxalement découverte dans l'un des sondages de la mer d'Okhotsk (mer de Kamtchatka, de BAILEY) effectués à des profondeurs de 1600 à 5000 m environ.

D'après BAILEY, ces sondages ne contenaient — outre des minéraux — que des organismes siliceux, aucun Foraminifère calcaire. Hormis notre Thécamoebien d'eau douce, les autres microorganismes de la liste (comme de la Planche), sont tous marins, y compris même la Diatomée *Pinnularia peregrina* EHR. (devenue *Navicula peregrina* (EHR.) KÜTZ), espèce parfois continentale, mais toujours saumâtre. Il est évident que la coque observée par BAILEY provenait du continent et avait pour origine un milieu aquatique. La presqu'île de Kamtchatka, sur sa côte ouest, possède plus d'une vingtaine de fleuves côtiers, déversant dans la mer d'Okhotsk les eaux d'un massif montagneux (avec des sommets de 3 à 4000 mètres), où les stations propices au développement des Thécamoebiens abondent. Il n'y a donc rien d'étonnant à ce que des apports de microorganismes continentaux soient suffisants pour que la vase de fond en contienne en proportion notable. Ce qui est seulement singulier, c'est l'absence, dans l'analyse de BAILEY, des Diatomées d'eau douce qui eussent été révélatrices de ces apports. On peut toutefois admettre qu'à l'époque (1856), les connaissances sur la systématique des Diatomées étaient encore trop vagues.

Le nom de *symmetrica*, créé par WALLICH en 1863 a été accolé par lui, dans le même travail, à *D. proteiformis* (p. 458) et à *D. pyriformis* (p. 467), cette dernière dénomination s'appliquant à sa figure reproduite ici. L'année suivante, WALLICH emploie encore *D. pyriformis var. symmetrica* dans son texte (p. 232) mais l'explication de la planche (p. 245) porte pour la première fois *D. symmetrica*. Dans ce travail WALLICH dit avoir examiné de nombreux exemplaires, provenant de la même station (mares de Hampstead) que les premiers décrits. Mais, en fait, WALLICH avait vu antérieurement encore, „deux

ou trois spécimens analogues dans un ruisselet tourbeux de la côte ouest du Groenland" — et il dit en avoir donné une figure dans la Part I. of „The North Atlantic Sea-bed" (Pl. 4, fig. 17). Nous ne connaissons pas cette figure qui serait apparemment la première relative à un individu recueilli in situ, dans son milieu normal.

On sait que, par la suite, EHRENBERG a figuré plusieurs fois le même Rhizopode — ou des formes voisines — sous des noms variés, dans le même volume des Abhandlungen de l'Académie de Berlin (1871): *Difflugia assulata*, *Difflugia carolinensis*, *Difflugia leptolepis*, *Difflugia tessellata*, *Difflugia capensis*. A vrai dire, le premier nom, *Difflugia assulata* se trouve déjà dans la Mikrogeologie d'EHRENBERG (p. 43), en 1854, et s'applique à une forme découverte par lui, au Liban, dont il ne publia un dessin qu'en 1871. Ce dessin reproduit ici fig. 4 — accompagné d'un autre, représentant la même espèce, provenant de „Guyana Roraima" — avait été exécuté par EHRENBERG vers 1848, mais il n'avait pas, sans doute, trouvé place dans l'Atlas de la Mikrogeologie. Ainsi, il faut bien reconnaître, une fois de plus, qu' EHRENBERG a été le premier à voir *Quadrulella symmetrica*, dans un échantillon d'humus, avec des mousses *(Polytrichum)*, et des Diatomées (dont *Pinnularia macilenta)* qui dénotent une station sinon aquatique du moins très mouillée. Cette station, près du village de Bischerre, au pied du mont Makmel, serait, d'après EHRENBERG, à quelques centaines de mètres au dessous de la forêt de Cèdres.

Les *Difflugia carolinensis* EHR. (Amérique du Nord) et *leptolepis* EHR. (Amérique du Sud) sont des formes typiques de *Q. symmetrica* (comme *D. assulata* EHR.), tandis que les *D. tessellata* EHR. et *D. capensis* EHR., du Cap de Bonne Espérance sont probablement à rapprocher de la var. *irregularis* PENARD, ou de la var. *longicollis* TARANEK.

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Studies on the Production and Utilization of Natural Food in Indonesian Carp Ponds [1])

K. F. VAAS & A. VAAS – VAN OVEN

Laboratory of Inland Fisheries, Bogor, Indonesia.

INTRODUCTION

The principal difference between Indonesian and European fish ponds is the fact that in the first case hardly any fodder is introduced and the fish subsist on natural food, the natural biota of the pond, sometimes encouraged by the introduction of sewage, kitchen waste, bran and green manure. Although some of these extraneous substances will be eaten directly by the fish, and notably by the common carp, natural food will always be the principal source of food.

It was the aim of our work to study the development of organisms serving as natural food for the common carp (*Cyprinus carpio* L.) in such ponds, their interrelationships, the influence of the carp on their quantitative and qualitative development and the utilization of those organisms by the fish.

The work carried out will be related in four sections.

In the first section a description will be given of the guts contents of 500 carp growing in a pond of the hatchery of the Laboratory of Inland Fisheries at Bogor, Java, from the moment the mouth and anus were formed until a total length of 135 mm was reached.

Owing to the large number of samples to be studied in the first section, supply of natural food could not be studied simultaneously. This was done in the experiments to be related in the second section, where the guts contents of the carp were studied together with the development of natural food during 4 growing periods. In compara-

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[1]) Published by permission of the Head of the Laboratory of Inland Fisheries.
The material of this article was circulated in mimeo-ed form in Indonesian for interdepartemental use by the Laboratory. Part of the material was presented at the 7*th* Meeting of the I.P.F.C. in Bandung in 1957, and will be published in abstract form in the Proceedings.

ble, unstocked ponds the development of biota was studied simultaneously in order to elucidate the influence of the fish.

In order to compare our Bogor findings with conditions in other ponds, 2 ponds at Sukabumi, Java, and 4 ponds at Palembang, Sumatra, were studied. The guts contents of the fish were compared with the supply of natural food in each case. These findings are given in the third section.

Finally an analysis is given of a sewage pond at Bodjong Loa, near Bandung City, where food supply and consequently food utilization by the carp proved to be totally different.

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SURVEY OF THE LITERATURE

Common carp has been cultivated in ponds in Central Europe for centuries and an extensive literature exists on its natural food in those ponds. In America this fish invaded many open waters and its feeding habits were related in a few recent papers.

The recent intensive carp culture in Israel also contributed to our knowledge on the subject. Although in Indonesia a good deal of experience with carp culture has been gathered, published records of investigations concerning its food in ponds are restricted to a brief statement by BUSCHKIEL (1938), to the effect that, under experimental conditions, carp fry consumed *Crustaceae* 3 days after hatching, *Tubificidae* 6 days, and *Chrironomidae* after 7–9 days. The older European literature has been summarized many times and need not be repeated here. The picture, as obtained from a study of the works of WUNDER (1936, 1949) on the food of the German cultivated carp, of MOEN (1953) on the free-living American carp, of KLUST (1940), VONK (1941) and JANCARIK (1956) on the functional anatomy and physiology of the digestive system and of many other papers, is about as follows:

After hatching the fry begin to take in food at an early stage.

According to various authors (KOSTOMAROV 1941, ALIKUNHI) 1951, MITRA & MOHAPATRA[1]) 1956), animal food gives far better growth than vegetable food. After feeding on plankton in the first stages the fry quickly turn to littoral fauna and afterwards to bottom fauna, taking in worms and larvae of aquatic insects together with vegetable food such as seeds, thread algae and vegetable detritus. However, contrary to what was held earlier by many other German authors, crustaceans are still important, as was specially emphasized by WUNDER.

All evidence goes to show that the common carp is able to use widely different kinds of natural food according to their relative availability and wide differences are often observed between the contents of the guts of entirely comparable carps grown up together in the same pond. Under special circumstances mass occurrence of a certain organism combined with the absence of others, the guts contents of carp may become quite unusual. In the sewers of Strassburg, for instance, the guts were crammed with *Vorticella*.

Other fishes and fry are sometimes eaten and KOSTOMAROV & HRABÉ (1943) succeeded in inducing cannibalism in overstocked ponds, beginning when the fish measured 12.8 cm. in length. The term „typical bottom-feeder", used for the common carp in older European literature, is not appropriate according to WUNDER, although bottom fauna and notably midge-larvae, are nearly always present and important.

According to WUNDER, MOEN and others, vegetable food is of secondary importance only, for all stages in the life of the common carp.

In order to be of importance as food for the carp a certain organism must occur in sufficient quantity and be obtainable and digestable. Many controversies between older European authors about the relative importance of *Crustaceae* and *Chironomidae* find their origin in differences between the availability of the organisms. Differences in size and fertility of the ponds and in climate often cause drastic changes in the biota of the pond available as food for the carp. However, to the sampling investigator availability is not similar to availability to the grazing carp.

WUNDER (1927, 1932) studied the question how the carp finds its food. By experiments in which carp were blinded and the sense of smell made ineffective, WUNDER found that sight and smell were comparatively unimportant and that even the sense of taste was not the principal means by which the carp selects it food, but rather the

[1]) The work of the Indian authors was carried out with the related Indian carps *Catla*, *Labeo* and *Cirrhina*.

sense of touch. Water is pumped into the mouth by the branchial apparatus and by the movements of the mouth, and organisms ingested are tested as to their palatability by the organs of taste and touch in the mouth and on the lips and barbels. Taking in a mouthful the fish extracts the nutriment and spits out the undesired residue. The intricate mechanism of the buccal apparatus enabling the carp to open its mouth was described by VAN DOBBEN (1937). Two different mechanisms were distinguished. By means of the first the mouth is opened widely and protuded along the longitudinal axis of the body, by means of the second mechanism the mouth is opened and pointed downwards. In this position the mouth is only partly opened and the caudal pair of barbels are pushed downwards. Thus they are in a favourable position to act as sense-organism for checking the food on the bottom. However, taking food from the bottom is not the only way of feeding. Drowned aerial and terrestrial insects, such as ants, are very often ingested and must be picked up from the surface.

Dividing the feeding activity of the fish into three stages WUNDER distinguishes a) alerting – the process by which the fish notices its food from afar, b) stalking – the process of approaching its prey and snapping it up, and c) the final checking of the food as to its suitability, when already grasped. He found that the eyes of the carp are of some importance in the first two stages. The enormous numbers of *Crustaceae* often found in the guts prove that a good deal of food is taken from the water and not from the bottom. Many authors found that plankton showed a different specific composition inside the guts than in the open water from which it had been collected. According to WUNDER this fact need not imply a process of specific selection by the fish. Very often *Crustaceae* occur in definite swarms, concentrated owing to phototropism or other factors. Once having noticed such a swarm the carp continues feeding on it. It should not be forgotten that the eye of the fish, although not adapted to see at long distances, acts as a hand-lens within very short distances. In such cases as when WUNDER found 100,000 *Daphnia's* in the guts of a large carp, it is impossible to assume ingestion by means of a simple straining action, or to assume that the carp picked the *Daphnia's* up individually, if they had been distributed evenly throughout the water. However, observing a carp feeding on a dense swarm of *Crustaceae* it is evident that by straining only a fairly large number can be ingested. Before the food passes into the gullet the molar-like pharyngeal teeth on the fifth branchial arch come into play, crushing the food against the horny plate attached to the ventral process of the basioccipital bone. In European carp these teeth are strong enough for mastication when the fry measure 1.2 cm.

With this apparatus the carp is able to crush the cases of *Trichoptera* larvae etc., spitting them out after ingesting the larvae. The action was studied in detail by KLUST (l.c.).

From the mouth the food passes on into the gullet and the intestine. In all *Cyprinidae* a proper stomach is absent as well as the pyloric caeca (appendices pyloricae), found in many other fishes. The ductus choledochus from the gall bladder has its aperture closely behind the oesophagus and, anatomically, this point always indicates the end of the stomach. Nowhere in the intestinal tract can cells producing pepsine or hydrochloric acid be found, which fact adds further proof for the complete absence of a stomach. Form and development of the guts of German carp were studied by KLUST (l.c.). There are no salivary glands in the mouth of the carp and in the intestine the glands described by LIEBERKÜHN for the mammalian guts are absent. There is a large liver and a gall bladder. The opening of the pancreas is next to that of the gall bladder on the upper right side of the intestine. As in many other fishes – notably in those without appendices phyloricae – the pancreas does not show as an individual gland, but can be traced as a diffuse organ divided into many branches along the intestine and various blood vessels, also penetrating the liver. Still it is possible to separate both tissues, as no true amalgamation does occur. (VONK l.c.).

Digestive enymes of the common carp were studied by VONK with modern methods. In this paper the older literature is summarized. VONK found a total absence of pepsine, but presence of: trypsine, erepsine, amylase and maltase.

Invertase, found in the closely related *Carassius auratus* L. by SARBAHI (1951), was absent in the carp. Those enzymes were found to be closely related to those of higher vertebrates. Besides being active in the usual way of emulsifying fats, the gall contains some amylase. The main production centre of amylase was found to be located in the pancreas. The enzyme is very active and has its optimal pH at 6.25. The pancreas produces inactive trypsine, to be activated by the enterokinase from the guts. The protein digestion is completed by erepsine, originating in the guts and practically absent in the pancreas. The optimal activity of both is found in an environment of pH 8–9. In the intestine of the living fish VONK found a pH between 6.73 and 7.71. Later authors confirmed most of VONK's findings. Lipase activity was found in the guts and in the liver and pancreas (JANCARIK l.c.). BONDI & SPANDORF (1951) showed that cellulose is digested by the live carp to an appreciable degree. However, no enzymes digesting cellulose or hemicellulose could be demonstrated in extracts from pancreas and intestine. Neither could any chitinase-activity be demonstrated.

The authors offer the possibility of an action of the bacterial flora in the intestine as a theoretical explanation although the presence of such a flora is contested by others (SNIESZKO 1957). They succeeded in demonstrating digestion of bran in vitro by extractions of the pancreas. This is an interesting finding, as bran is so often used in Indonesian carp ponds. KLUST reported that amylase and lipase of small fry was less active than that of adult fish.

During World War I, German physiologists such as KNAUTHE, ZUNZ and CRONHEIM, endeavouring to account for the erratic results obtained by German carp growers with fodder, formulated an interesting theory. Starting from the assumption that the secretions of pancreas and guts would be insufficient to break down vegetable food, they thought that the enzymes of the *Crustaceae*, *Oligochaetae* and *Chironomidae*, taken in as food, cooperated with those of the carp.

These animals themselves subsist on vegetable matter and their digestive tract contains enzymes in large quantities. In the opinion of the authors mentioned the importance of natural food for the carp must be sought in the better digestion caused by the action of these exogenic enzymes.

At that time the enzymes of the carp were insufficiently understood and it was thought that carp could not subsist on artificial food alone.

After the laboratory experiments of SEILER (1938) this opinion cannot be upheld. Her experiments clearly show that carp can thrive on artificial food alone — in some cases even better than on natural food- provided the food shows the correct ratio between nitrogen and carbon in its chemical composition. The evident importance of natural food for ponds where artificial feeding is intensively practized, is thought to be a supply of vitamines (see. e.g. YASHOW 1954, TAL 1956).

SCHÄPERCLAUS (1953) accepted the above hypothesis only in case of the enzymes derived from *Chironomidae* and not for those from *Crustaceae*, because he thought that the peptic ferments of those animals would cease their activity forthwith in an alkaline environment. KLUST (l.c.) feeding carp alternately on potatoes and on potatoes with live *Daphnia*'s did not find an increase in the percentage of starch grains broken down. However, SCHLOTTKE (1938) found that after feeding on worms a more active extract could be prepared from the guts of carp than after a diet of fishmeal and sugar. JANCARIK (l.c.) studied extracts from worms, *Crustaceae* and *Chironomidae*. He found all of them-therefore, contrary to the opinion of SCHÄPERCLAUS, the *Crustaceae* too — to be active at a pH of 8.1. A mixture of such extractions with enzymes from the carp showed considerable increase in digestive activity and this author is therefore of the opi-

nion that exogenic enzymes are most important for digestion in the intestine of the carp. The activating influence of such enzymes is not restricted to the digestive enzymes of the organisms ingested, but autolytic enzymes also come into play.

Summarizing all available evidence pertaining to our problem we arrive at the following picture:

The common carp, feeding mainly on natural food will be fully able to digest proteins and carbohydrates including cellulose, but excluding chitine.

External chitinous sceletons will be crushed by the pharyngeal teeth so as to make the inside of the organisms accessible to the action of the digestive enzymes.

The velocity of the process of digestion — the time the food stays inside the guts — is accelerated by increased temperature more or less in accordance with VAN 'T HOFF'S law. (VON MALTZAN 1935, KARSINKIN 1935). The rate of filling affects the speed of digestion in the guts even stronger than temperature. (KLUST l.c.). When the guts are filled to capacity the food remains inside for a short time, but when the guts are sparingly filled it remains much longer.

Moreover when the guts are crammed with food the enzymes do not properly reach the food. Similar phenomena are found in many other animals and are caused by the peristaltic movements of the guts, studied in the common carp by VON MALTZAN (l.c.), who found great similarity with other vertebrates. KLUST (l.c.) studied the time natural food stayed in the guts of German common carp at a temperature of 17°. In accordance with older workers he found periods of 4—5 hours, which means that the carp completely fills its guts 4—5 times a day, provided that feeding does not stop during certain hours. KLUST did not find any evidence of a definite „siesta", contrary to WUNDER (1936), who observed carp in Silesia resting without taking any food from 5—7 p.m.

Many authors have studied the efficiency of digestion in fish, either in vitro or with the living animal, using chemical substances or the organisms themselves. (KARSINKIN l.c. MANN 1935, KLUST l.c.).

Their findings can be summarized as follows:

The efficiency of digestion is unaffected by changes in temperature. *Oligochaetae* are easily digested, prongs and patches of the empty skin being the only remains. *Cladocera* are easily digested, parts of the skins, legs, brood-cases with eggs and guts, are found in the faeces. Probably the eggs are still viable after leaving the anus. *Cyclopidae* are often even better utilized than *Cladocera*. *Ephemeroptera* larvae and other insect larvae are rather easily digested, parts of the chitinous skeleton and of the legs forming the only remains. *Chironomidae* are less easily digested, the less so the older and larger they are.

The tough chitinous skin resists penetration by enzymes. Some could be „revived" after a period of 3 hours in the guts.

Many authors agree that single-celled algae are either partly digested or not at all. (WIRSZUBSKY 1948, 1953, ALIKUNHI l.c.). Already in 1928, LANGHANS & POLLAK were able to cultivate *Chlorella* and *Scenedesmus* from faeces of the common carp, thus proving that many cells were not digested. The present authors did the same in Bogor.

As our experiments do not deal with the utilization of fodder supplied from outside, the extensive literature on this subject will not be discussed here.

SECTION 1.

GUTS CONTENTS OF THE COMMON CARP, GROWING IN A POND OF THE HATCHERY AT BOGOR, FROM THE MOMENT THE MOUTH AND ANUS ARE FORMED UNTIL A TOTAL LENGTH OF 135 MM IS REACHED.

MATERIAL AND METHODS

On January 29th 1956 some mature carps were spawned with the result that about 150 gram of eggs adhered to the fibers of the „kakaban"[1]). Transfered to an ordinary pond of the hatchery, these eggs developed into about 25,000 larvae of about 5 mm in length, without functional intestinal tract, mouth or anus and with a well developed yolk sac. On Febr. *2nd.* the swim bladder was filled, the yolk sac was partly absorbed, and intestinal tract-measuring 130 μ in its widest part-was formed. The animals, having filled the swim bladder with air, were able to swim and chase their own food. The first sample was taken that day.

The pond measured 205 m^2 and received the rather limedeficient water of the Bogor hatchery having a neutral reaction, but it was fertilized by adding 50 kg of stable manure and 50 kg green manure every week. The fish were given a small dose of rice bran each day, after the regular sampling was completed in the early morning. No bran was found in the guts, it being completely digested within 24 hours, so that feeding did not interfere with our purpose of testing the intake of natural food during growth from the hatching until the consumption stage.

As the fish increased in size, the stock had to be thinned out, so as to ensure good growth. This was done as shown in table I.

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[1]) Indonesian name for the fiber-mattings used in spawning the common carp.

TABLE I

Size and number of the fish during the experiment.

Period	Date	Number	Initial size in mm.
I	2/2	25000	7—8
II	23/2	5000	18
III	23/2	2000	39
IV	26/4	1065	50
V	27/6	200	75
cropped	13/8	134	136

During the last two periods resp. 10 and 4 large mudjairs (*Tilapia mossambica P.*) were stocked together with the carp in order to suppress a too extensive growth of *Spirogyra*.

During the last month the carp were sexually mature.

Regular sampling was carried out: from 2/2 until 31/3 every other day, from 31/3 until 25/5 every fifth day and from 25/5 until the end every tenth day.

Each sample consisted of 10 fish, gathered with nets and immediately preserved in formaline. In total 50 times 10 fish were examined. Each time the crop was thinned out a new supply of water was given to the pond, during the experiment a steady, slow supply of water was maintained.

Not earlier than one day and not later than five days after sampling the fish were cut open and the entire intestinal tract was removed. The contents were pressed out and the guts cut open to remove all contents. In the case of very small fry the contents could be counted under the microscope, but in the case of larger amounts aliquot samples had to be counted. For this purpose all contents were washed into stoppered funnels and allowed to settle during 24 hours. The following day the quantity was measured with the aid of a calibration previously fixed on to the stems of the funnels. A fraction of the contents was then studied microscopically and care was taken that this fraction was never less than about 1/6 of the total amount. In most cases this quantity amounted to 1/3 or more. The remainder was allowed to settle another day and measured on the third day. In this way a multiplication factor was established and the numbers counted could be related to the numbers present in the whole sample. Towards the end of the experiment several guts had to be cut into sections and more than one funnel had to be used for one fish. Allways all data of the 10 carp forming the sample were combined and treated as a unity. This was done because often differences were found between entirely comparable carps growing together in the same pond and also sampled together. By taking 10 fish together each time we tried to minimize the effect of those differences. In the

third Section some examples of individual differences will be shown. Each organism encountered was identified as far as possible. In the intestine the food is present in a crushed, broken and cut condition. Still it is possible to identify most organisms from their remains. The heads of the *Chironomidae*, their guts still filled with detritus, the tracheae of the pupae, the empty, wrinkled skins with rows of chaetae of the *Oligochaetae* and the shells, and eggs of the *Crustaceae*, all make these organisms conspicuous. As was stated earlier, some organisms are not digested. These were not listed. Serious difficulties are encountered in the numeration of many organisms and nearly all authors mentioned above have commented on this subject. Thread algae and vegetable remains are often partly digested, which fact has to be taken into account when ultimately their nutritive importance has to be evaluated.

The carp always has a good deal of mud and detritus in its guts, picked up from the bottom of the pond. For this reason single chaetae of *Oligochaetae* and fragments of the shell of snails do not prove that the live organisms were ingested. If, however, empty skins with rows of chaetae are found, together with operculae and radulae of snails it becomes highly probable that these organisms have served as food.

After counting and listing all identifiable remains found, during which process the rate of digestion was taken into account, all numbers were converted into volumes, with the aid of special standards established previously as the result of repeated measurements. It follows from what was stated above that the figures obtained must be considered to be estimates. It is doubtful whether exact figures can be obtained in the case of a fish ingesting detritus and mud as does the carp (HYNES, 1950). It is hoped that the large number of samples studied by our method will counteract the relatively arbitary standards of our final evaluation.

Upon studying methods for the examination of intestinal contents, as critically summarized by HYNES (l.c.) and PILLAY (1952), we have chosen the procedure described below. All food was divided into groups. First it was established how many times each group was found in the guts. In the second place it was established how many times each group formed the main part of the contents by volume and sometimes also how many times it ranked second place. Finally the total volume was given in the form of tables and in some tables it was computed into a percentage of the total contents. In this way the importance of each group could ultimately be judged by three separate standards.

As was stated above, conclusions about feeding were based on the evidence offered by 500 analyses of guts contents. As it is impossible to relate all data here, only summaries and illustrative examples will be given.

As regards their importance as food for the carp, all biota can be divided theoretically into the following groups:

1. Organisms living in the pond, but not ingested by the carp. In this respect it should be noted that certain organisms are ingested in the later stages and not in the earlier, as the fish is then too small.
2. Organisms ingested, but only partly digested or not at all. Some organisms are poorly digested when occuring in small numbers in the guts, but distinctly better utilized when present in bulk.
3. Organisms ingested and digested but, owing to the small numbers present, not of any quantitative importance as a source of food.
4. Organisms present, fully digested and occuring in sufficient quantities to form an important item of the diet.

It should be added that the carp does also ingest other food besides living or decaying organisms namely, vegetable detritus, either from autochthonous or from allochthonous origin. Among the organisms of the first group we found in our pond: Tadpoles and adult frogs small fishes such as *Lebistes* and *Puntius binotatus*, Crabs and large aquatic insects, together with the later and larger stages of their larvae, such as *Sphaerodema*, *Notonectidae*, *Velidae*, *Cybister* and *Gyrinus*, which insects themselves prey upon the small carp fry. A description of the biota in the pond will be given in the second Section. Several single-celled, small green algae belong to the group that was ingested but not at all or not fully digested. They were found throughout the guts with quite green chromatophores and often so viable that sterile media, inoculated with faecal matter taken from the anus by means of sterile capillaries, showed a marked growth after a short time. *Scenedesmus*, *Eudorina* and *Pandorina* could be grown in this way. *Desmids — Cosmarium*, *Euastrum*, *Staurastrum* etc. — were usually partly digested, the large cells of *Closterium* usually far better. *Euglena*, often occuring in the pond in bulk, was some times ingested by the very small fry and partly utilized.

Filamentous blue-green algae, such as *Oscillatoria* and *Lyngbya* were poorly digested and the same was found for *Spirogyra*. However, this alga often occurs in bulk and may be taken by the fish in partly decaying condition. In that case the carp will derive a certain amount of food from this source. Whether a fully digestable

organism will be of quantitative importance or not, obviously depends on its occurrence in the pond, but also on the dimensions of the fish.

According to our findings the food of the carp and carp fry in our pond, can be divided into 9 groups as follows:

1. *Chironomidae*. Besides larvae and pupae belonging to the Subfamily of *Tanypodinae* and *Chironominae*, Sectio *Chironomiriae* and Sectio *Tanytarsiae*, we wish to include in this group the *Ceratopogonidae* of the *Bezzia*-type. As the livespan of the larvae is so much longer than that of the pupae, the latter were but sparingly represented.
2. Other Insects. Mainly larvae of other aquatic insects, such as *Ephemeridae*, *Odonata* and *Coleoptera*. Terrestrial insects, such as ants, accidentally fallen into the water, are often eaten.
3. *Crustaceae*. Although in our original files those animals are divided into *Cladocera*, *Cyclopidae* and *Ostracoda* (*Cypris* spp.) they are jointly mentioned in the summaries given in the present paper. Frequent genera were *Macrothrix spinosa* KING (adult females and juveniles, adult males few), *Diaphanosoma* spec., *Ilocryptus longiremis* SARS and *Mesocyclops* spec. These *Crustaceae* were kindly identified by DR. H. H. F. HAMANN, Bogor, who took up the study of these organisms in ponds and their remains in the guts of the carp at our request and to whom our indebtitude is due.
4. *Oligochaetae* of the genera: *Dero*, *Limnodrilus*, *Nais* and sometimes *Branchiura Sowerbyi* BEDD., were often encountered. As pointed out by KLUST (1935) it is very difficult to establish the exact number of these worms in the guts, owing to their delicate structure and the very high digestibility.
5. *Gastropoda*. Many crushed shells (*Limnaea*) and also some radulae and opercula of such snails as *Melania* and *Vivipara* (*Paludina*) were found. These animals are most frequent in the pond. Their total number can only be estimated as entire shells are rare. The body itself does not leave any recognizable traces after digestion.
6. *Closterium*. This large-celled Desmid often occurs in bulk in the water and may be taken in appreciable numbers, mainly by the very small fry. Not all cells are completely digested.
7. *Rotatoria* and their eggs are an important item for tiny fry. The cells are completely digested, but only of quantitative importance when taken in bulk.
8. *Protococcales*, *Flagellatae* and *Protozoa* are grouped together. They are important only for the very small fry, as will be seen from the tables, and completely without value at the later stages. In addition to the organisms mentioned earlier we wish to cite: *Phacus* and *Arcella*.

TABLE II. *Frequency. Relative Importance in volume and total volume of nine items of feed for the Common carp at Bogor. Chronological order.*

	First Period 2/2—23/2 from hatched fry till length of 18,35 mm. Total number of fish 110.			Second Period 23/2—23/3 from 18.35 mm till 39,35 mm Total number of fish 150.			Third Period 23/3—27/4 from 39,85 mm till 50 mm. Total number of fish 100.			Fourth Period 27/4—27/6 from 53,8 mm till 79.7 mm. Total number of fish 90.			Fifth Period 27/6—14/8 from 87.3 mm —136,6 mm. Total number of fish 50.		
	Frequency Max. 110.—	Rel. Importance I+II	Total Volume in 110 fish (in mm³).	Frequency, Max. 150.	Rel. Importance I+II	Total Volume in mm³ for 150 fish.	Frequency, Max. 100.	Rel. Importance I+II	Total Volume in mm³ for 100 fish.	Frequency, Max. 90.	Rel. Importance I+II	Total volume in mm³ for 90 fish.	Frequency, Max. 50.	Rel. Importance I+II	Total volume in mm³ for 50 fish.
Chironomidae	58	37+ 19	59	137	84+ 42	273	86	33+ 23	159	73	12+32	228	49	23+17	1586
Other Insects	24	14+ 6	58	67	33+ 16	268	63	20+ 21	272	36	3+13	115	34	2+ 3	249
Crustaceae	91	47+ 47	88	147	21+ 72	427	99	12+ 34	517	88	20+18	580	50	17+18	1915
Oligochaetae	12	—+ 3	1,6	28	—+ 6	—	31	4+ 2	5	5	—+—	—	17	—+—	—
Gastropoda	—	— —	—	22	—+ 1	40	33	7+ 8	216	22	2+ 7	131	3	—+—	—
Closterium	47	—+ 2	0,3	100	3+ 7	65	64	—+ 1	13	14	—+—	—	—	—+—	—
Rotatoria	78	11+ 12	0.1	84	1+ 1	—	29	—+ —	—	12	—+ 1	8	6	—+—	—
Protococcales Flagellata Protozoa +	96	1+ 21	0.1	26	—+ —	—	13	—+ —	—	—	—+—	—	—	—+—	—
Plant tissue thread algae +	—	—+—	—	37	8+ 5	95	80	24+ 11	317	90	53+19	609	43	8+12	557
TOTAL		110 110			150 150			100 100			90 90			50 50	

TABLE III. *Frequency, Relative importance and total volume expressed in percentages.*

	Frequency in percentage					Percentage of importance I + II					Percentage of Volume				
Period	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Chironomidae	52,7	91,5	86	81	98	33,6+17,3	56 +38,1	33+23	13,3+35,3	46+34	28,5	23,4	10,6	13,6	37
Other insects	21,8	44,6	63	40	68	12,7+ 5,5	22 +10,7	20+21	3,3+14,5	4+ 6	28	28	18,1	6,9	5,8
Crustaceae	83	98	99	98	100	42,7+42,7	19,1+47,4	12+34	22,2+23,4	34+36	36,8	36,8	34,5	34,8	44,5
Oligochaetae	10,9	18,6	31	5,5	34	— + 2,7	— + 4	4+ 2	— +—	—+—	0,4	0,4	0,3	—	—
Gastropoda	—	14,7	33	24,5	6	— +—	— + 0,7	7+ 8	2,2+ 7,8	—+—	—	3,0	14,4	7,8	—
Closterium	42,7	67	64	15,5	—	— + 1,8	2 + 4,7	—+ 1	— +—	—+—	0,1	5,6	0,9	—	—
Rotatoria	71	56	29	13,3	12	10 +10,9	0,7+ 0,7	—+—	— + 1,1	—+—	0,05	—	—	0,5	—
Protococcales + Flagellatae + Protozoa	87	17,3	13	—	—	0,9+19,1	— + 0,7	—+—	— +—	—+—	0,05	—	—	—	—
Plant tissue + Thread algae		24,7	80	100	86	— + —	5,3 + 3,2	24+11	59 +21	16+24	—	8,1	21	36,4	13
Number of carps	110	150	100	90	50	Total 100%					Total 100%				
Duration of period in days	21	29	35	61	47										

9. Thread algae, mainly *Spirogyra* and *Hydrodiction*, are listed together with plant tissue, derived from higher aquatic plants such as *Hydrilla verticillata*, and detritus of allochthonous origin, in our case also from decaying *Tithonia* leaves thrown in as green manure.

With the aid of the above explanations the tables illustrating the guts contents of the carp during growth will be understood.

THE DIET OF THE COMMON CARP IN THE BOGOR HATCHERY

The overall results of the five successive periods are given in table II in terms of frequency, relative importance judged by total volume, and total volume in mm^3. In table III the figures have been converted into percentages.

From a study of these tables we wish to draw the following conclusions, discussing the nine groups in turn.

1. *Chironomidae* are found to form a most important item, even for the very young fry. In the samples of the first period some head-capsules of *Chironomidae* were measured, in order to compare the dimensions of the prey with those of the predator.

   Table IV — an extract from our files — gives an idea of the importance of midge-larvae for the very young stages of carp under the circumstances observed, during the first period.

TABLE IV

Numbers and dimensions of Chironomid larvae found in the guts of carp fry, immediately after hatching. (First period) Number of fry: 10 carp each date.

Date	Days after hatching	length of fry in mm	Chironomidae number	Chir. width of head-capsule in μ
2/2	2	7.50	2	100
4/2	4	8.82	4	180
6/2	6	11.25	2	—
8/2	8	12.35	0	—
10/2	10	14.45	20	300
12/2	12	14.00	12	—
14/2	14	15.40	20	—
16/2	16	16.90	35	387
18/2	18	17.40	17	—
20/2	20	17.00	18	—
22/2	22	18.35	54	—

In this table the data for each date are the averages, (width) c.q. the sums (number) for 10 fry. It will be seen that *Chironomidae*

were eaten from the very first day food was ingested and that these larvae increased in importance throughout the period. By comparing the first with the following periods it will be seen that later on *Chironomidae* still increase and remain important throughout growth. However, it is also evident that these larvae do not hold the primary position ascribed to them by many European authors. The difference found in our case might be explained by a different availability of other sources of food. In the extreme environment of the „karamba's"[1]) in the sewers of Bandung, for instance, *Chironomidae* and *Oligochaetae* actually formed the main source of food. (VAAS & SACHLAN, Proceedings of I.P.F.C. 6th Meeting, Tokyo, in the press.).

2. Other aquatic insects and their larvae were taken in many cases and in increasing numbers as the fry grew older. Their importance is always less than that of the midgelarvae. Living in the open water or among the littoral flora most of them belong to a quite different ecological group. As will be shown in the next Section these animals are far less frequent than midge-larvae.
3. *Crustaceae* — *Cyclopidae*, *Cladocera* and *Ostracoda* — formed the most important item from the beginning of growth to the end of our experiment, according to all three criteria.
   In this case the ideas of WUNDER on this group were fully confirmed. On the 4th of February fry of an average length of 8.82 mm consumed *Cyclopidae* measuring 260μ in width. In later stages large numbers were often found in a single intestine. On the 14th of July 16137 *Cyclopidae* were found in the guts of 10 carp measuring 108.6 mm in average length. The largest number encountered in one fish was 6900.
4. *Oligochaetae* were neither frequent nor important in our pond. For an entirely different situation we refer again to the Bandung „karamba's". Here mass-availability caused this group to be of primary importance.
5. *Gastropoda* were not ingested in the first stages, the digestive apparatus of the fry being, probably, too weak to crush the shells of even the smallest snails. They gained some importance later on.
6. *Closterium*. In this case the opposite situation is found. These large cells were eagerly ingested by the very young fry, but gradually lost their importance and were not eaten at all in the last stage. The total quantity was always small.
7. *Rotatoria* hold a position similar to that of *Closterium*.
8. *Protococcales*, together with *Flagellatae* and *Protozoa*, show the characteristics of the two previous groups in an even more

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[1]) bamboo cages where carp are grown in running sewage.

pronounced way. Owing to the small size of the cells they do not materially add to the volume of food ingested by the tiny fry. As was stated above, the digestibility is bad and these cells are not ingested any more when the carp has reached a larger size.

Diatoms were often ingested but never in appreciable quantities.

9. Plant tissue and Thread algae are not ingested during the first period. From the third period on this item is most frequent and is found during the three later periods with frequencies of resp. 80—100 and 86 %. In 24—59 and 16 % of all cases it formed the main food by volume, occupying resp. 21—36.4 and 13 % of the food by volume. For these figures digestibility had to be estimated. The volumes used for calculation were those that were estimated to be actually digested. Consequently vegetable food of this type formed an important item in our case, although less important than each of the groups of *Chironomidae* and *Crustaceae*. Teh weekly supply of horse-manure and *Tithonia* twigs will have increased the availability of easily digestible vegetable food in our pond.

   In Europe VON MALTZAN (l.c.) emphasized its importance and vegetable tissue and grass seeds *(Glyceria)* have been found in the guts by many authors. This is in accordance with the use of cereals and pulses as fodder. However in WUNDER's numerous analyses this group was not so important. MOEN (l.c.) investigating the food of 687 carp from 14 lakes in Amerika, found that vegetable debris, pieces of the tissue of living aquatic Phanerogames and seeds were taken, forming about 10 % of the food in summer, but almost entirely absent in winter, and mainly ingested when other food was scarce.

   In many cases carp were reported to destroy aquatic vegetation in American open waters (CAHN 1929, THREINEN & HELM 1954), and experiments, especially designed by TRYSON (1954), had the same results. However, this is not the effect of consumption of the plants by the carp, but of the vigorous way large carp churn up the bottom mud in search of food and thus uproot the plants and increase the turbidity of the water so as to intercept sunlight indispensable for vegetation.

   Comparing the evidence obtained according to the three different criteria, we arrive at the following order of importance, shown separately for fish smaller than 40 mm — periods I and II — and for those larger than 40 mm — periods III, IV and V. (Table V).

The difference between small and large fry — importance of single-celled algae and *Rotatoria*, absence of *Gastropoda* — was already mentioned above. Aquatic insects and their larvae form

TABLE V

Order of importance of nine categories of food, according to three criteria, for carp measuring less than 40 *mm, and for carp measuring from* 40—135 *mm total length.*

Carp less than 40 mm.

FREQUENCY	REL. IMPORTANCE	TOTAL VOLUME.
Crustaceae	Chironomidae	Crustaceae
Chironomidae	Crustaceae	Insects
Rotatoria	Insects	Chironomidae
Closterium	Rotatoria	Plant tissue
Protococcales etc.	Plant tissue	Closterium

Carp from 40—136 mm.

Crustaceae	Plant tissue	Crustaceae
Chironomidae	Chironomidae	Plant tissue
Plant tissue	Crustaceae	Chironomidae
Insects	Insects	Insects
Closterium	Gastropoda	Gastropoda

fairly large individual quantities of food. If a small fish happens to catch them, they contribute materially to the total volume ingested. This explains the high order of this group in the case of the smaller fry.

The primary position of *Crustaceae* and *Chironomidae* stands out clearly in this table. Vegetable food seems to have been playing an important role mainly during the long fourth period, probably the regular supply of *Tithonia* and horse manure had some influence here.

It is of interest to compare these results with those of WUNDER, being a summary of the examination of the guts contents of 534 large carp from Silesian ponds, and given in table VI.

TABLE VI

Composition in % of the guts contents of 534 *large crap from Silesian ponds. Measurements by weight.* (*after* WUNDER 1949).

	planktonic	littoral	bottom	total
Crustaceans	57	3	—	60
Chironomidae	—	10	7	17
Other Insects	—	23	—	23
Total	57	36	7	100

This table was based on calculations from which the amount of vegetable food was omitted, because — according to WUNDER — this was not important.

It will be seen that planktonic *Crustaceae* exceeded the midge and

other larvae taken from the bottom and the littoral zone. WUNDER's ponds in Silesia are materially deeper than ours.

This might explain the difference in the importance of vegetable food, of which relatively more will have been present in our pond — both from autochthonous and allochthonous sources — than in WUNDER's ponds. From these findings WUNDER drew the conclusion that his carp were not typical „bottom feeders" and we can support this statement. As our pond is much shallower than those studied by WUNDER, its bottom - fauna must be relatively more important than the *Crustaceae* of the littoral zone and the open water. Still we find *Crustaceae* to be of primary importance.

RELATIONSHIPS BETWEEN FOOD AND GROWTH

In the previous chapters only overall results per period have been given. However, if we try to analyse the relationships between the quantity and quality of food ingested and growth measured in terms of increase in length of body and guts, as well as in terms of the changing ratio between length and body height of the fish, some interesting points are revealed.

Studying fig. 1 and 2, where the 5 periods are shown in two figures, using different scales for length of body and guts and for volume of guts contents in either case, we see that in the first four periods growth of body and intestine starts rapidly and slows down towards the end. As the last period was rather short, growth was interrupted here before it began to slow down. The ratio between length and height of the fish decreases rapidly at first and slowly afterwards, showing that the fry becomes relatively higher as it grows. During the periods of slow growth of body and intestine this ratio shows temporary interruptions in its downwards slope.

In these figures every point concerning measurements of the body of the carp is an average of 10 fish taken at random out of a number decreasing every time the pond was thinned out, (table I) and every point concerning volume of intestinal contents depicts the total quantity of the guts of 10 fish.

On the 13 *th* of Augustus when the experiment ended, it was possible to check the accuracy of sampling. Previous to the cropping of the entire population a sample of 10 was taken in the usual way. The average length of those 10 fish was 13.66 cm. Then the remainder was landed and all 134 fish measured. The average length proved to be 13.56 $\pm$ 0.081 cm, with a standard deviation = 0.938.

For this reason it is assumed that all previous samples were representative as well.

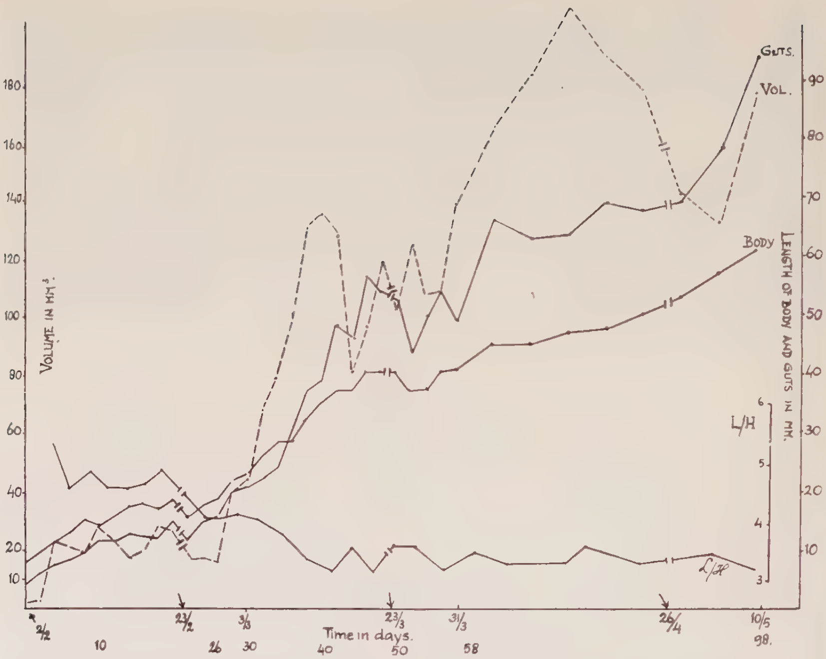

Fig. 1. Growth of the body and the guts of common carp fry in ponds in Bogor, together with the total quantity of digestable food in the guts of 10 fish and the ratio between total length and height of the body (average of 10 fish). First part.

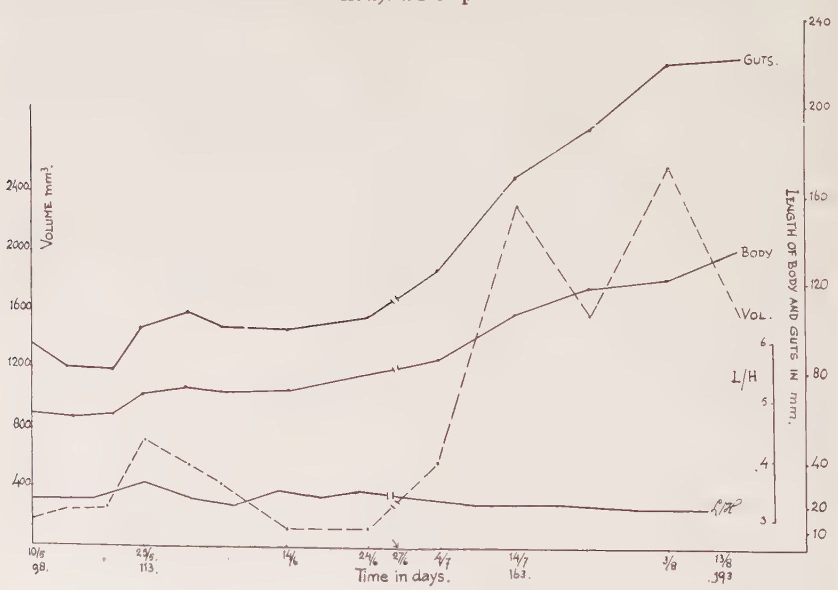

Fig. 2. As Fig. I, second part (different scales)

It will be seen that the volume of food ingested also shows a decline towards the end of each period, concomitant with the general decline in the rate of growth. It seems that under the conditions studied, after one month certain limiting factors come into play decreasing the amount of natural food suitable for rapid growth. In the next Section, where biota were sampled simultaneously with guts contents, more will be said on this subject.

In figs. 3, 4, 5, 6 and 7 the volumes of the various groups of natural food of quantitative importance are separately shown for every period

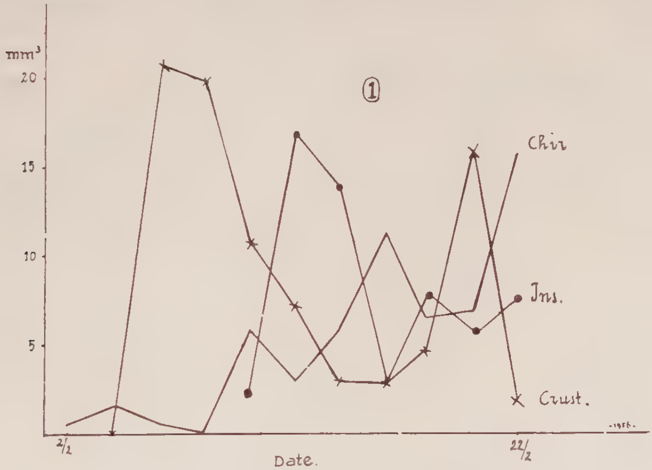

Fig. 3. Changes in composition of the guts contents during growth. Total volume for 10 fish. First period.

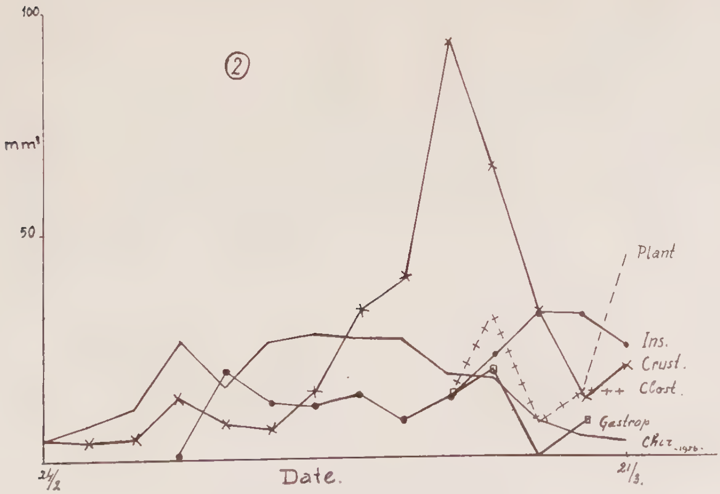

Fig. 4. As Fig. 3. Second period.

Fig. 5. As Fig. 3. Third period.

Fig. 6. As Fig. 3. Fourth period.

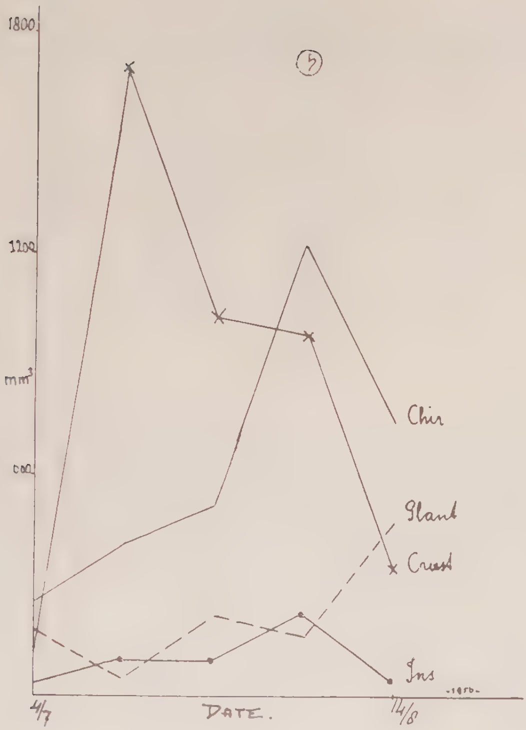

Fig. 7. As Fig. 3. Fifth period.

of growth. As availability of food in the pond was not studied at this stage, it is difficult to analyse the feeding habits of the growing carp here.

All writers who studied this phenomenon agree that the occurrence of pond-biota is most erratic and that sudden rises and falls are common for many organisms. As the carp is a pronounced polyphagous species, availability will dictate its food to a marked extent.

Besides showing polyphagous feeding habits the carp shows pronounced individual differences in its choise of food, as was evident in nearly all our samples, where always 10 carp feeding under exactly similar conditions were examined. We have tried to circumvent this disturbing influence by using the sum of the guts contents of 10 fish each time.

If we study the different lines for each group in the figures, we find that a large majority of them roughly show an optimum curve, with the exception of the line for vegetable food, which in 3 out of 4 cases shows an increase towards the end. (Table VII).

TABLE VII

General trend of graphs showing the fluctuations of the total volume of various groups of natural food in the guts of 10 carp, during 5 periods of growth.

Period	I	II	III	IV	V
Chironomidae	rising	optimum	optimum	rising weakly	optimum
Other Insects	optimum	optimum weak	optimum	optimum	optimum
Crustaceae	optimum	optimum	optimum	optimum	optimum
Gastropoda	—	—	optimum	falling	—
Plant tissue + Thread algae	—	rising	rising	optimum	rising

These findings seem to indicate that towards the end of each period, when growth slows down owing to scarcity of other food, more vegetable food of inferior nutritional value, is taken in.

For European and American common carp similar views are held by most authors, as was stated in a previous chapter. It will be seen that in our findings vegetable food formed a larger percentage, and was more often ingested, than in most cases abroad.

This must not be seen as a preference but as a necessity arising from a shortage of other food, and as a result of the supply of horse — and green manure, making easily digestable vegetable food readily available.

SECTION 2.

RELATIONSHIP BETWEEN THE GUTS CONTENTS OF COMMON CARP GROWING IN A POND OF THE HATCHERY AT BOGOR AND AVAILABILITY OF NATURAL FOOD, SIMULTANEOUSLY SAMPLED. INFLUENCE OF THE CARP ON DEVELOPMENT AND GROWTH OT OTHER POND BIOTA.

MATERIAL AND METHODS

The experiments to be related in this Section were carried out in order to supplement our previous findings with data on the availability of natural food organisms and also to study the influence of the carp on development and growth of those organisms.

For this reason 4 ponds of the Hatchery, entirely comparable to the one mentioned in the first Section, were used. Two were stocked with common carp, two were left unstocked. Every week the following observations were made:

1. Netplankton, from 10 litre.

Table VIII.

Guts contents of 30 common carp grown in 4 ponds of the Bogor Hatchery during 4 growing periods.

	Frequency (Max. 30)					Relat. Import. I + II					Volume all fish mm³					Volume all fish %				Average %
Experiment no.	1	2	3	4	Tot.	1	2	3	4	Tot.	1	2	3	4	Tot.	1	2	3	4	
Chironomidae	4	7	8	6	25	3+1	2+0	1+5	3+3	9+9	81	86	37	33	237	31	30	7	15	21
Other insects	3	4	2	1	10		1+0			1+0	28	14	4	1	47	11	5	1	—	4
Crustaceae	4	7	8	10	29	1+3	3+2	7+1	6+2	17+8	130	79	461	164	834	50	27	87	73	59
Oligochaetae	—	2	—	2	4						2	3	—	2	7	1	1	—	1	1
Gastropoda	1	6	3	2	12		0+2	0+2		0+4	10	57	14	3	94	4	20	3	1	7
Closterium	1	1	—	1	3				1+1	1+1		2	—	10	12	—	—	—	4	1
Plant tissue + Thread algae	3	7	4	4	18		2+4		0+4	2+8	6	49	12	12	79	3	17	2	5	7
Number of carp	4	8	8	10	30			do.					do.				do.			
Length of carp in cm.	$\frac{9.5}{12}$	$\frac{4.0}{7.6}$	$\frac{5.9}{8.3}$	$\frac{3.0}{5.5}$				do.					do.				do.			

2. Nannoplankton from 10 litre, using the Iodine-sedimentation method.
3. Organisms from the mud. Eight samples of 1 cm^2 were taken with a glas rod at different places of the pond.
4. Weight of 10 carp taken with a small bow net. A small amount of faeces was gently pushed out of the vent and immediately preserved in formaline. The carp were than released.
5. Guts contents of various other pond biota.
6. Littoral fauna and microflora was studied in 10 one-litre samples taken along the entire embankment of the pond. The data obtained are shown in the tables in a semi-quantitative way only.

At the end of each period two to five fish from each pond were cut open and the entire guts sampled. A total number of 30 carp was studied.

The experiment was repeated 4 times with different stocking rates according to the momentary availability of fry. Stocked and unstocked ponds were changed each time, in order to avoid cumulative effects and possible effects of minor topographic differences. This arrangement has the disadvantage of the possibility of after effects of previous stocking in unstocked ponds. Another unavoidable disadvantage was the change of the seasons. The first period — August — took place during the dry, the fourth during the rainy season. However there differences are not comparable to seasonal changes in temperate zones.

Out of every plankton sample 0,02 cc was counted twice. Numbers were converted to volumes as in the previous Section, and expressed per litre.

Mud samples were treated as plankton samples after all organisms larger than 1 mm had been picked out by hand under a binocular microscope. *Chironomidae* and *Oligochaetae* formed the bulk of the latter group.

Faeces were treated as guts contents. After the volume of each group had been ascertained they were expressed in the tables as percentages of the total amount. Total volume is irrelevant in this case as the total quantity will be erratic.

Organisms too big to be sampled with the net or the tube were not studied quantitatively but some specimens were regularily taken and their guts contents studied in the lab. Some names have been mentioned earlier.

RELATIONSHIP BETWEEN DIET OF THE COMMON CARP AND AVAILABILITY OF NATURAL FOOD.

In total the entire guts contents of 30 carp were studied. As Rotatoria and organisms in previous tables combined into the groups *Protozoa*, *Flagellatae* and *Protococcales*, proved to be unimportant for these, somewhat bigger, fish both groups were deleted in the tables.

In table VIII the guts contents are shown according to the same criteria as used in previous tables.

It will be seen that the results of each of the four growing periods do not differ much and that the overall results are similar to those obtained in the previous experiment. As no additional green manure was added this time less vegetable matter was found in the guts.

In table IX the different groups were listed according to their importance as natural food for the common carp using the three criteria separately.

TABLE IX.

Importance of natural food for 30 *common carp grown in Bogor Hatchery in* 4 *periods.*

Frequency	*Relative Importance*	*Volume*
Crustaceae	Crustaceae	Crustaceae
Chironomidae	Chironomidae	Chironomidae
Plant tissue	Plant tissue	Gastropoda
Gastropoda	Closterium	Plant tissue
Insects	Gastropoda	Insects
Oligochaetae	Insects	Closterium
Closterium		Oligochaetae

The order according to the different criteria is exactly the same for the two most important groups and does not differ much for the others.

Again *Closterium* was only important in those cases that small fry was used (Exp. no 2 and 4).

The relationship between guts contents and instantaneous supply of natural food is shown in tables X, XI, XII and XIII. Here the guts contents are shown for the total number of fish from each pond separately in each period. The numbers of organisms are shown and not the volumes as in previous tables because the same was done for food supply. Pond biota were sampled every week but only the data for the dates of cropping are shown because at these days the guts were collected. In accordance with the way of sampling, as described earlier, the data are divided into biota from the open water, from the mud on the bottom and biota among the shore vegetation. It must be admitted that organisms found in the guts have been ingested by the

TABLE X.

Numbers of organisms encountered in the guts of carp growing in ponds of the Bogor Hatchery and pond biota sampled simultaneously. Experiment no. 1. *Cropped on* 11/10, *ponds* 11 *and* 14.

	Guts contents	Pond biota			Guts contents	Pond biota		
	2 carp	Plankton 1 litre	Mud 8 cm²	Littoral 10 litre	2 carp	Plankton 1 litre	Mud 8 cm²	Littoral 10 litre
Chironomidae	80		1	x	194		1	
Other Insects				x	24			x
Crustaceae	176	575		x	934	125		x
Oligochaetae	18							
Gastropoda			x		13		x	
Closterium					6			
Rotatoria		6925		x		1000		x
Protococcales		550		x				x
Protozoa		25				75		x
Plant tissue					x			
Thread algae				x	x			
Diatomeae	xxx	14000	110000	x	x	4600	95000	x
Desmidiaceae		250						
Euglena		600				850		x
Nauplius larvae		675				575		
Length carp in cm	10—12.1				9.5—10.2			
Pond no.			11				14	

TABLE XI.

Numbers of organisms encountered in the guts of carp growing in ponds of the Bogor Hatchery and pond biota sampled simultaneously. Experiment 2. Cropped on 15/11, ponds 12 and 15.

	Guts contents	Pond biota			Guts contents	Pond biota		
	5 carp	Plankton 1 litre	Mud 8 cm²	Littoral 10 litre	3 carp	Plankton 1 litre	Mud 8 cm²	Littoral 10 litre
Chironomidae	53		4	x	230			
Other Insects	8			x	5			x
Crustaceae	685			x	161	675		
Oligochaetae	1		2		52			
Gastropoda	147			x	150			x
Closterium	130	25				25		
Rotatoria		275		x		875		
Protococcales	25	200		x				x
Protozoa		25						
Plant tissue	xx			x	xxx			x
Thread algae	72			x				x
Diatomeae	25	76300	635000	x	29	275	575000	x
Desmidiaceae								
Euglena		72	x	x		275		x
Nauplius larvae		50				800		
Grass seeds	xxx			xxx	xxx			xxx
Length carp in cm	4.0—7.2				6.2—7.6			
Pond no.			12				15	

TABLE XII.

Numbers of organisms encountered in the guts of carp growing in ponds of the Bogor Hatchery and pond biota sampled simultaneously. Experiment 3. Cropped on 14/12. Pond 11 and 14.

	Guts contents	Pond biota			Guts contents	Pond biota		
	3 carp	Plankton 1 litre	Mud 8 cm^2	Littoral 10 litre	5 carp	Plankton 1 litre	Mud 8 cm^2	Littoral 10 litre
Chironomidae	114		1		88		1	
Other Insects	2			x				x
Crustaceae	3294	1325		x	1365	825		x
Oligochaetae							2	
Gastropoda	x			x	x			x
Closterium					29			
Rotateria		325		x		700		
Protococcales		25		x		300		
Protozoa								
Plant tissue								
Thread algae	x				x			
Diatomeae	8	59900	73500	x		1750	92500	x
Desmidiaceae		75						
Euglena		23925		x		60775		x
Nauplius larvae		725		x		675		
Grass seeds		xx			x			x
Length of carp in cm	7.1—8.3				5.6—6.9			
Pond no.			11				14	

Numbers of organisms encountered in the guts of carp growing in ponds of the Bogor Hatchery and pond biota sampled simultaneously Experiment 4. Cropped on 17/1. Ponds 12 and 15.

	Guts contents	Pond biota			Guts contents	Pond biota		
	5 carp	Plankton 1 litre	Mud 8 cm^2	Littoral 10 litre	5 carp	Plankton 1 litre	Mud 8 cm^2	Littoral 10 litre
Chironomidae	32		3	x	80		2	
Other Insects	1		1	x				x
Crustaceae	1330	550		x	644	375		x
Oligochaetae	10				6			x
Gastropoda	x			x	x			x
Closterium	479				19			
Rotatoria	5	2050		x		9050		x
Protococcales		250				50		x
Protozoa						25		x
Plant tissue								
Thread algae	117							
Diatomeae	15	300	448000	x	xx	1050	235000	x
Euglena		1250		x		1350		x
Nauplius larvae		425				1325		x
Grass seeds	x				x			
Length of carp in cm	3.0—5.5				3.2—4.1			
Pond no.			12				15	

The first groups shown in these tables are the ones used in the previous tables concerning guts contents, the later groups contain organisms found in the pond and either not taken in by the carp or of no quantitative importance. For this reason *Closterium* was separated from the other *Desmidiaceae*.

carp some hours earlier than those sampled from the pond at the moment the fish were caught.

Previous studies revealed a slight diurnal movement of *Crustaceae* in our ponds (VAAS & SACHLAN, 1955), rising to the surface at night. Thus *Crustaceae* might have been slightly more readily available to the carp, feeding in all strata of the water, than is revealed in our samples, where 10 times 1 litre was taken. However in the third Section carp were collected every 4 hours during a period of 24 hours and no reliable differences were found in the numbers of *Crustaceae* in the guts.

Table XIV gives a list of the organisms of the ponds ecosystem.

TABLE XIV.

List of biota living in the ponds of the Bogor Hatchery.

Plankton	
Volvocales	Pandorina, Eudorina.
Chlorococcales	Dictyosphaerium, Golenkinia, Pediastrum, Scenedesmus.
Desmidiaceae	Cosmarium, Closterium.
Diatomeae	Melosira, Navicula
Chloromonadineae	Euglena.
Cyanophyceae	Nostoc, Lyngbya.
Rotatoria	Filinia, Asplanchna, Rotifer, Brachionus, Polyarthra, Cathypna.
Crustaceae	Bosmina, Diaphanosoma, Macrothrix, Ilyocryptus, Mesocyclops, Cypris.
In the mud samples	
Coelenterata	Hydra.
Oligochaetae	Nais, Branchiodrilus, Pristina, Dero, Aulophorus, Limnodrilus, Branchiura.
Chironomid larvae	Tanytarsus, Eutanytarsus, Chironomus, Endochirinomus, Limnochironomus, Tendipes, Glyptotendipes, Pelopia, Macropelopia, Protenthes.
Mollusca	Melania, Paludina.
Nematoda	
Not quantitatively sampled:	
Crustaceae	Paratelphusa
Insecta	Notonectidae, Corixidae.
Pisces	Lebistes
Amphibia	Frog larvae.

Based on the data of the above tables, supplemented with the evidence obtained from a study of the guts contents of various other biota, the following picture is obtained of food relations within the ecosystem of the pond.

The guts contents of the common carp have been described. In the guts of *Lebistes* we found the same organisms but for *Gastropoda.*

Planktonic *Crustaceae*, adult aquatic insects and *Rotatoria* subsist mainly on phytoplankton, barring some aquatic insects attacking fish fry. Moreover *Rotatoria* eat bacteria from the water and from the upper layers of the mud. *Crustaceae* also eat minute phytoplankton und epiphyton from the vegetation around the bunds and detritus. The *Ephemeridae* larvae found among the littoral flora subsist on epiphyton and phytoplankton. *Oligochaetae*, *Chironomidae* and snails ingest the mud on the bottom, consisting of organic detritus of allochtonous origin, the remains of dead plants and animals, the bacteria responsable for the decay of the organic substances and the benthic algae taking in the released minerals.

Tadpoles and crabs take up an exceptional position in so far that these organisms, living exclusively on vegetable matter — in the guts of the crabs coarse plant material only was found — and for this reason accelerating metabolic processes in the pond, are hardly ever eaten by other animals in this environment. Minerals are stored in their bodies for this reason. Tadpoles will eventually leave the pond after completing their metamorphosis and crabs can crawl to some other pond and are captured by the hatcherymen during cropping.

This qualitative picture might suffice at this stage for our present aim, a comparison between the supply and utilization of natural food in these ponds. The ecosystem will be referred to in greater detail after the description of quantitative relations in the second part of this chapter. At the end of the paper conditions in these Bogor ponds will be compared with those in a pond at Bodjong Loa, Bandung.

It will be seen in the above tables that the food organisms encountered this time and also during the investigations related in the first section, in the guts of the common carp were readily available, either in the open water — *Crustaceae* — or in the mud — *Chironomidae* and *Oligochaetae* and some *Gastropoda* —, or among the littoral flora — insect larvae. The large supply of *Diatomeae*, *Protococcales*, *Euglena* is not touched. Among the *Desmidiaceae* only the large *Closterium* is of some importance. The small-celled *Rotatoria* are hardly taken. *Nauplii* were frequently found in the pond but could never be ascertained in the guts. Severe crushing of the cells inside the guts makes identification difficult. So we are not in a position to state that *Nauplii* are not eaten at all.

The picture obtained in the first section, that the carp is a polyphagous, opportunistic feeder of natural food whenever available in the form of not too small size in the open water, on the bottom and among the shore vegetation, is confirmed.

In the second part of this section the study of our weekly samples taken in the pond and supplemented with the investigations of the faeces of the growing carp, will be treated in an attempt to study the

continuous changes in the composition of the biota as a result of the feeding activities of the carp. Here the weekly samples taken in the unstocked ponds will have to act as controles. With the methods described a fairly quantitative picture can be obtained of the supply of organisms forming the main food of the carp — *Crustaceae*, *Chironomidae* and *Oligochaetae*, as well as of those organisms making up the main food of the *Crustaceae* — phytoplankton. The supply of food for both *Chironomidae* and *Oligochaetae* could not be evaluated, but this supply might be assumed to be large, as benthic algae will grow profusely in these lively inhabitated ponds, where sunlight can reach the entire bottom. Dead and live algae will be readily available on the bottom. Moreover the number of *Chironomidae* larvae depends on the number of eggs and the number of ovipositing females will be independent from the amount of food on the bottom. According to experiments by SADLER (1934) and WIRSHUBSKY & ELCHUNES (1952) more eggs are deposited in ponds previously treated with organic manure. However inorganic fertilizers do not show this phenomenon and in the latter case the availability of food on the bottom will be increased as well. The effect of manuring is thought to consist of the production of chemical substances attracking the imagines.

The organisms counted were divided into the following groups:

1. Phytoplankton (both net- and nannoplankton) barring *Euglena*. This organism is often found in enormous numbers as a surface film, frequently accumulated in a corner of the pond by wind action. For this reason it is difficult to obtain reliable samples and moreover the large numbers could influence the phytoplankton data to a marked extent. The cysts of *Euglena* are undigestable for many organisms and for all these reasons we wish to treat *Euglena* separately from other algae sampled with the plankton net. In giving separate values for *Euglena* we are well aware of their relative unreliability.
2. Rotifera.
3. Nauplius larvae. Subsisting on phytoplankton and some detritus, these larvae are apparently not eaten by our carps and only to a limited extent by *Lebistes*. Their number depends on the number of adults able to produce them before they are devoured themselves.
4. *Chironomidae* are combined with the usually less frequent *Oligochaetae*. They live on detritus- barring the few carnivorous species[1]) and are eaten by the carp.

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[1]) Although *Pelopia* is a carnivorous genus according to the literature, we only found vegetable matter in the guts and never any animal remains.

The numbers of these organisms were converted into volumes. In the tables and figures showing the results of the relevant experiments the average weight of 10 fish is likewise shown, forming together a growth curve of the carp. These 10 carp were restocked after some faeces were pushed out of the vent. In the tables and figures the weekly percentage of *Crustaceae* and *Chironomidae — Oligochaetae* is shown. The four experiments will be described separately.

Experiment 1.

10/9 untill 11/10. Ponds 12 and 15 unstocked, ponds 11 and 14 stocked with 120 carp, total weight 770 gram. Results: pond 11 cropped 106 carp, total weight 1673.5 gram — increase: 903.5 gram , pond 14 cropped 91 carp, total weight 1380 gram — increase 610 gram.

Data pertaining to this experiment are given in table XV and figures 8 and 9. After one week an outburst of phytoplankton occurred in all ponds composed of *Dictyosphaerium* and *Melosira*. After two weeks nearly all *Chlorococcales* are absent, the phytoplankton consisting of *Melosira* and some other Diatoms only. Although *Melosira* does occur in fairly large numbers the total volume is seen to decrease owing to the small volume of the Diatoms compared with other algae. The bloom of the phytoplankton during the first week is much higher in the stocked ponds. Among *Rotatoria Asplanchna* is conspicuous, attaining high values in both stocked ponds during the third week. In the unstocked pond no 15 a bloom caused by *Polyarthra* was seen.

The numbers of *Crustaceae* are seen to follow those of phytoplankton with a lag of one week. Although these animals are eagerly devoured by the carp they are found in the stocked ponds in greater numbers. Benthic organisms are seen to increase untill the second or third week and are declining afterwards. In general numbers are higher in unstocked ponds notably the final values.

The percentual composition of the faeces shows that during the first weeks *Crustaceae* formed the principal food. As supply declines benthic fauna is increasing and the fish draws on this source accordingly, reducing their numbers. As the growth curve shows a decline during the last week a situation of overstocking did exist.

It is evident that here fish have accelerated metabolic feeding cycles as phytoplankton developed so readily. It seems that development of *Crustaceae* was more dictated by availability of food than by grazing and on the other hand development of benthic organisms more by grazing.

A comparison between the food of the carp and that of *Lebistes* is given in table XV. It follows that, when supply is plentiful, the

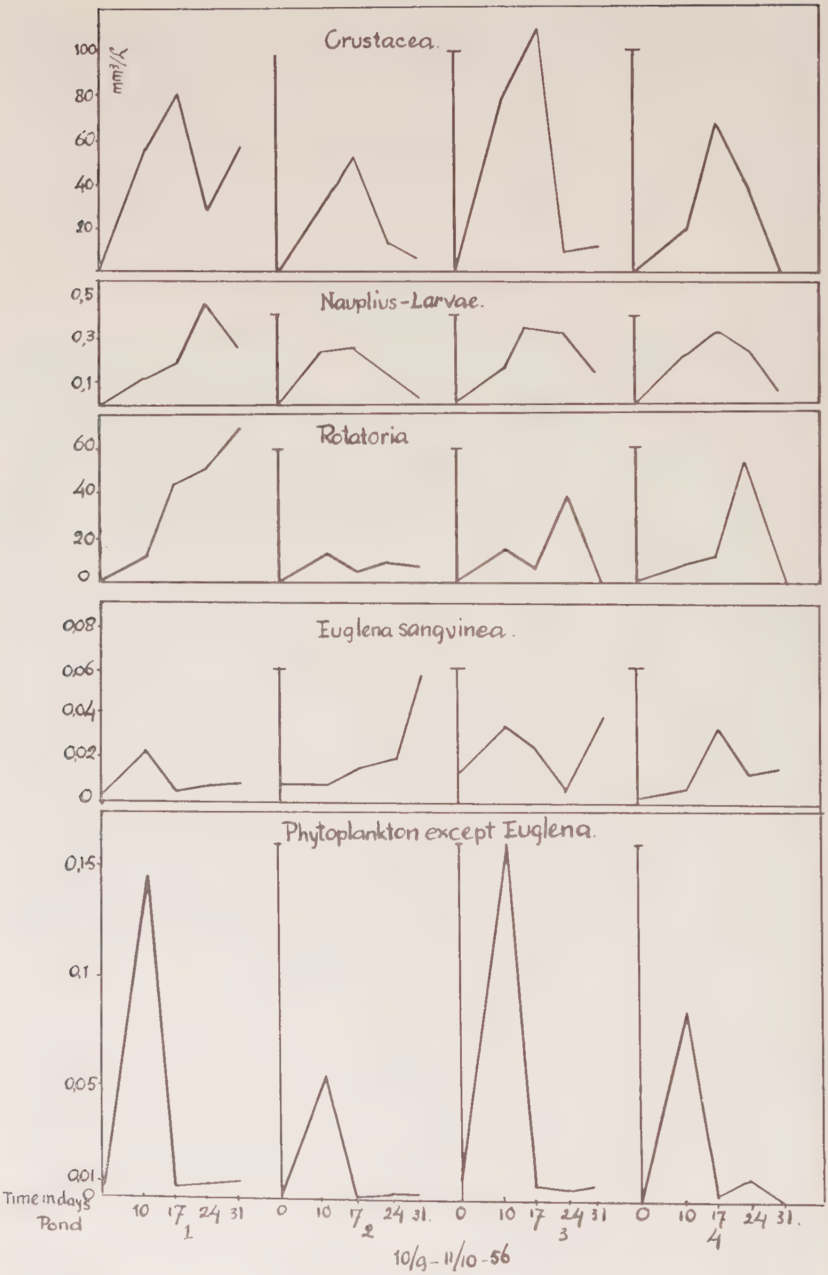

Fig. 8. Development of plankton in stocked (11 and 14) and unstocked (12 and 15) ponds in Bogor.

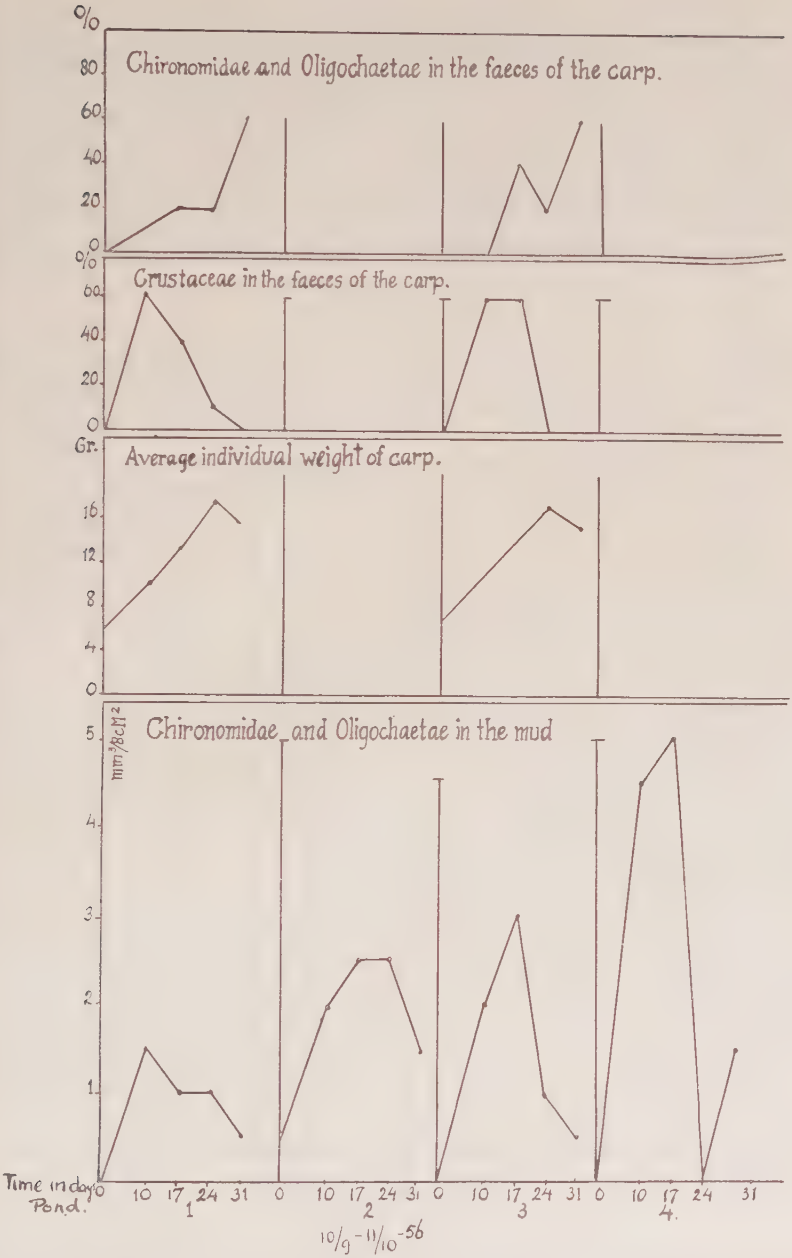

Fig. 9. Percentages of Crustaceae and Chironomidae in the faeces of the carp. Growth curves of carp from ponds 12 and 15. Development of organisms in the mud of stocked (11 and 15) and unstocked (12 and 15) ponds.

Table XV.

Guts contents of Common carp compared with Lebistes. Ponds 11 and 14, Experiment 1, at three dates.

Date	27/9				4/10				11/10			
Pond	11		14		11		14		11		14	
Fish	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.
Chironomidae	x	x			xx				xx	x	xx	
other Insects									x		x	
Corixidae	x											
Notonectidae										x		x
Ephemeridae				x								
Oligochaetae					x	x	xx	x	x			
Crustaceae	xxx		xxx	xx			x	x	xx		xx	xxx
Nauplii			x			x						
Gastropoda												
Rotatoria											x	
Nematoda							x					x
Diatomeae					x	x			xxx			xxx
Oscillatoria						x		x	xx			xxx
Lyngbya										x		
Merismopedia						x		x		x		x
Closterium								x		x		x
Euglena							x					
Thread algae											x	
Plant tissue					x	x	x	x		x	x	x
Mud			x		x	x		x	xx	x	x	x

diets are nearly the same. However, when supply of *Crustaceae* and *Chironomidae* is failing *Lebistes* turns to plankton — *Cyanophyceae*, *Rotatoria* and *Nauplii* —, organisms too small for the carp. This fish will turn to detritus, snails and benthic algae in stead. (The samples taken 27/9 and 4/10 were faeces taken from live fish, the sample taken on 11/10, at the end of the period contained entire guts contents, for this reason no comparison between the first two samples and the third one should be made, only between both fishes).

Experiment 2.

15/10 untill 15 11. Ponds 11 and 14 unstocked, ponds 12 and 15 stocked with 800 carp, total weight resp. 272 and 288 gram.

Results: pond 12 cropped 620 carp, total weight 1063 gram — increase 791 gram. pond 15 cropped 533 carp, total weight 853 gram — increase 565 gram.

Data pertaining to this experiment are given in tables XVI and XVII and figures 10 and 11.

In this experiment a bloom of *Euglena sanguinea* made clear cut conclusions difficult. Already at the beginning of the period large numbers of *Euglena* were encountered. Probably these flagellates, having developed in the previous period, remain on the mud bottom after draining and are immediately present after the pond is refilled. When samples were taken during the second week a strong wind had accumulated the surface film in one corner of the pond and hardly any were sampled in the plankton. Some days after filling in all ponds a bloom of *Pandorina* was seen, however after a few days this alga disappeared. During the following weeks the phytoplankton was dominated by *Diatomeae*, notably *Melosira* and *Navicula*. The only reliable difference between stocked and unstocked ponds was that no. 12 contained more *Diatomeae* than all others, however a similar difference was not found in the other stocked one, no. 15. However in the nannoplankton of this pond large numbers of *Richteriella* were found 17 days after filling.

This phenomenon does not show in the figures owing to the small volume of the organisms concerned. Both *Rotatoria* and *Crustaceae* show a distinct maximum in the stocked ponds after resp. 10 and 17 days. It might be assumed that development of phytoplankton has been larger here, but that the algae were immediately consumed by the zooplankton.

No difference between numbers of *Chironomidae* and *Oligochaetae* in the mud of stocked and unstocked ponds could be ascertained here, but these animals were also found to be less important elements of food in the guts of the carp.

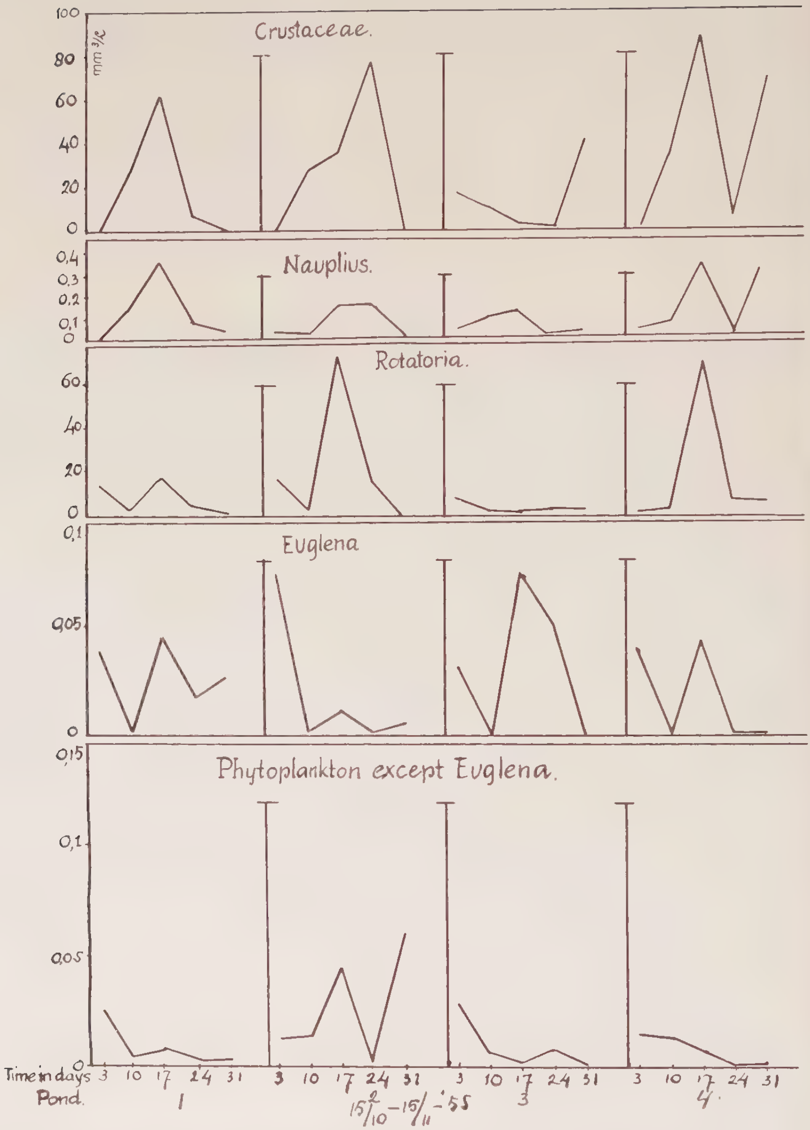

Fig. 10. As Fig. 8. Second experiment. Ponds 12 and 15 stocked, ponds 11 and 14 unstocked.

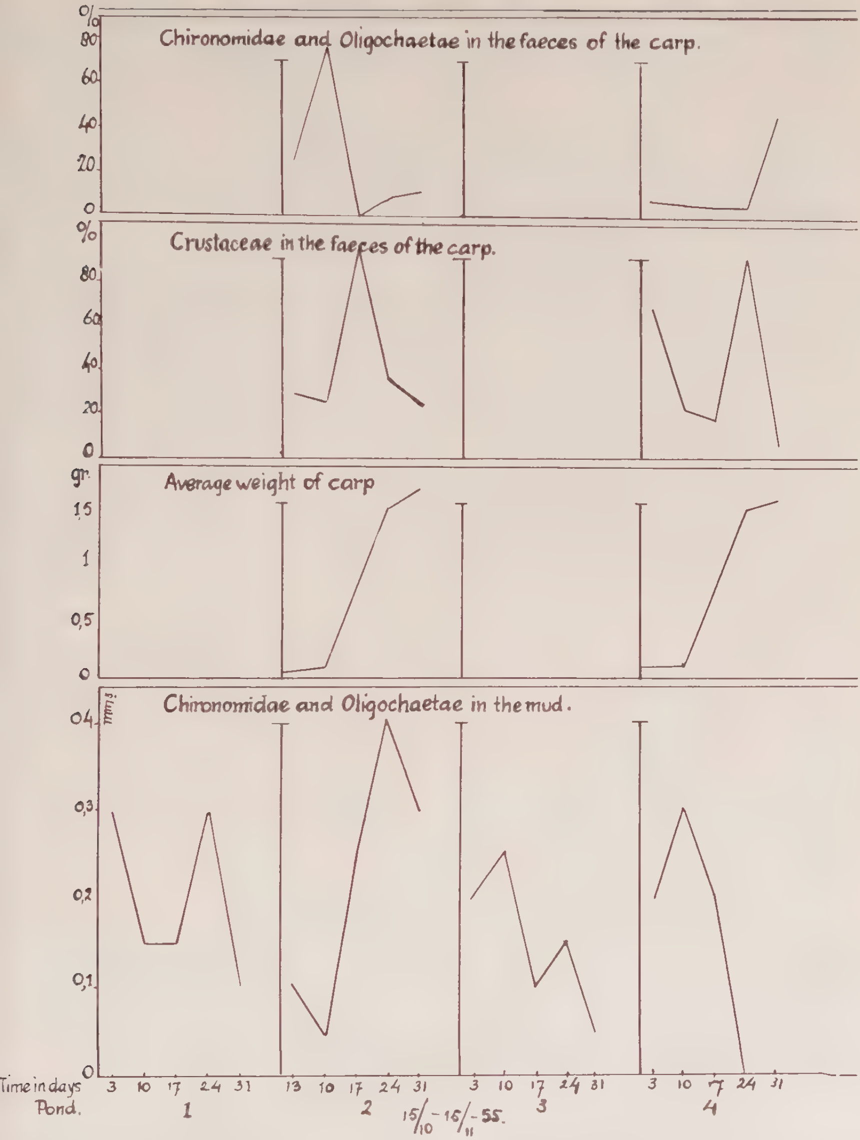

Fig. 11. As Fig. 9. Second experiment. Ponds 12 and 15 stocked, ponds 11 and 14 unstocked.

Only in pond 12 during the second and in pond 15 during the last week a fairly large number of these animals was encountered in the guts and their number in the mud was found to decrease accordingly.

A survey of the analysis of faeces of live carp is given in table XVI. In confirmation of earlier findings it was found that these small fishes used *Rotatoria* as additional food and that in certain cases hard, unidentifiable seeds of higher plants (grasses?) formed a large fraction of the contents.

If follows from a comparison between the guts contents of carp and Lebistes (table XVII) that in this case too the main food is usually the same but that differences may occur in the additional food. These sources are mainly drawn upon when the supply of *Crustaceae* is low. Competition for *Chironomidae* did not seem to be so severe in this case.

The stocking rate in this experiment was calculated so as to make the product of the number stocked multiplied with the average weight per carp raised to the power 2/3 about aqual to a similar value used in experiment 1.

This calculation is based on the fact — well known in animal physiology — that the amount of food needed for maintenance of the body of an animal is proportional to the surface of the animal, which value may be taken to be proportional to the weight derived to the power 2/3. The total amount of maintenance food for all carp in the pond can be estimated in this way. (vide VAAS-VAN OVEN, Third Fisheries Training Centre F.A.O./Indon, Governm. Bogor 1955 to be published by F.A.O.)

The above mentioned values were: $800 \times 0{,}35^{2/3} = 400$ for Experiment 2 and $120 \times 6{,}4^{2/3} = 420$ for Experiment 1.

As the amounts of maintenance food needed must be theoretically the same, the ponds should have yielded similar amounts of fishflesh, provided development of natural food had also been the same. It is seen that the yields differed to a marked extent and it follows from a comparison between the various growth curves (figure 11) that this time the ponds were not overstocked.

It might be assumed for this reason that the small carp used here did not yet fully utilize the available food, notably in the beginning of the period, with the result that a fraction is not utilized at all or eaten by other organisms. In this way the entire metabolic rate of processes operating in the pond is slowed down and development of food during the period was lower. By the time the carp were able to use the food to full extent, other organisms have already incorporated too much minerals and no bloom of phytoplankton took place, individual growth slowed down. The ponds must be considered to

TABLE XVI.

Percentage of volume of various organisms in faeces of live carp during Experiment 2.

Pond	12					15				
Date	18/10	25/10	1/11	8/11	15/11	18/10	25/10	1/11	8/11	15/11
Chironomidae	25	75		8	10.5	6.7	6	5	5.6	40
other Insects			4	1	1	11		3		
Oligochaetae										9
Crustaceae	29	25	96	35	23	68	22	18	91	6
Gastropoda					42					
Rotatoria	21					5.3				
Phytoplankton	11					5.2				
Spirogyra				1	2.5			2		
Seeds				55	10		73	71	3	10
Plant tissue	14				10	5.4				35

TABLE XVII.

Guts contents of Common carp compared with Lebistes. Pond 12 and 15, Experiment 2, at four dates.

Date	18/10				25/10				8/11				15/11			
Pond	12		15		12		15		12		15		12		15	
Fish	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.
Chironomidae	x		x		xx		x				x		x	x	xx	
other Insects			x													
Crustaceae	x		x	x	x	x	x	x	xxx	x	x	xx	x		x	x
Nauplii		x					x									
Gastropoda													xx		xx	
Rotatoria	x	x	x	x	x											x
Phytoplankton	x	x	x	x										x		
Spirogyra																x
Plant tissue	x	x	x		x		x						x		x	

be understocked in this case. In an article by the second author (VAAS- VAN OVEN, in the press) to be published in the near future by the Indo-Pacific Fisheries Council, the relationships between stocking rate and development of natural food in carp ponds is treated. More evidence will be found there that the supply, utilization and incorporation of minerals act as limiting factor of fish production.

Experiment 3.

16/11 untill 14/12. Ponds 12 and 15 unstocked, ponds 11 and 14 stocked with 250 carp, total weight resp 260 and 270 gram.

Results: pond 11 cropped 125 carp, total weight 1165 gram — increase 915 gram. pond 14 cropped 212 carp, total weight 980 gram — increase 710 gram.

Data pertaining to this experiment are given in table XVIII and figures 12 and 13.

In this experiment *Euglena sanguinea* occurred in increasing numbers throughout ponds 12, 14 and 15. Phytoplankton consisted throughout the experiment of *Diatomeae*, mainly of *Melosira* and *Navicula*. As in both previous experiments these *Diatomeae* showed a better development in the stocked ponds.

A striking difference between the stocked and unstocked ponds in this experiment was a marked outburst of *Crustaceae* after two weeks in the unstocked ponds, to be replaced by *Rotatoria* one week later, whereas in the stocked ponds the number of *Crustaceae* was rather low in the beginning but increased towards the end. The number of *Nauplii* was seen to increase too and no bloom of *Rotatoria* did occur. Numbers of *Chironomidae* and *Oligochaetae* were distinctly higher in the unstocked ponds.

In accordance with supply the percentage of *Crustaceae* encountered in the faeces was seen to increase throughout and the percentage of *Chironomidae* was found to decline.

In pond no 11 heavy losses took place and the remaining carp had the opportunity to grow on. Losses were much lower in pond 14, but as the fish did not grow at the end and actually decreased in weight, total yield at the end was much lower.

Although it might be expected that the amount of maintenance food needed by the carp was lower in this case than in both previous experiments ($250 \times 1^{2/3} - 250$) — still it must be concluded that both ponds were overstocked on the strength of the evidence offered by the growth curves.

Probably the heavy outburst of *Euglena*, an organism not offering much food to various other biota owing to its hardy cysts, exerted an unfavourable influence on total development of food in the ponds.

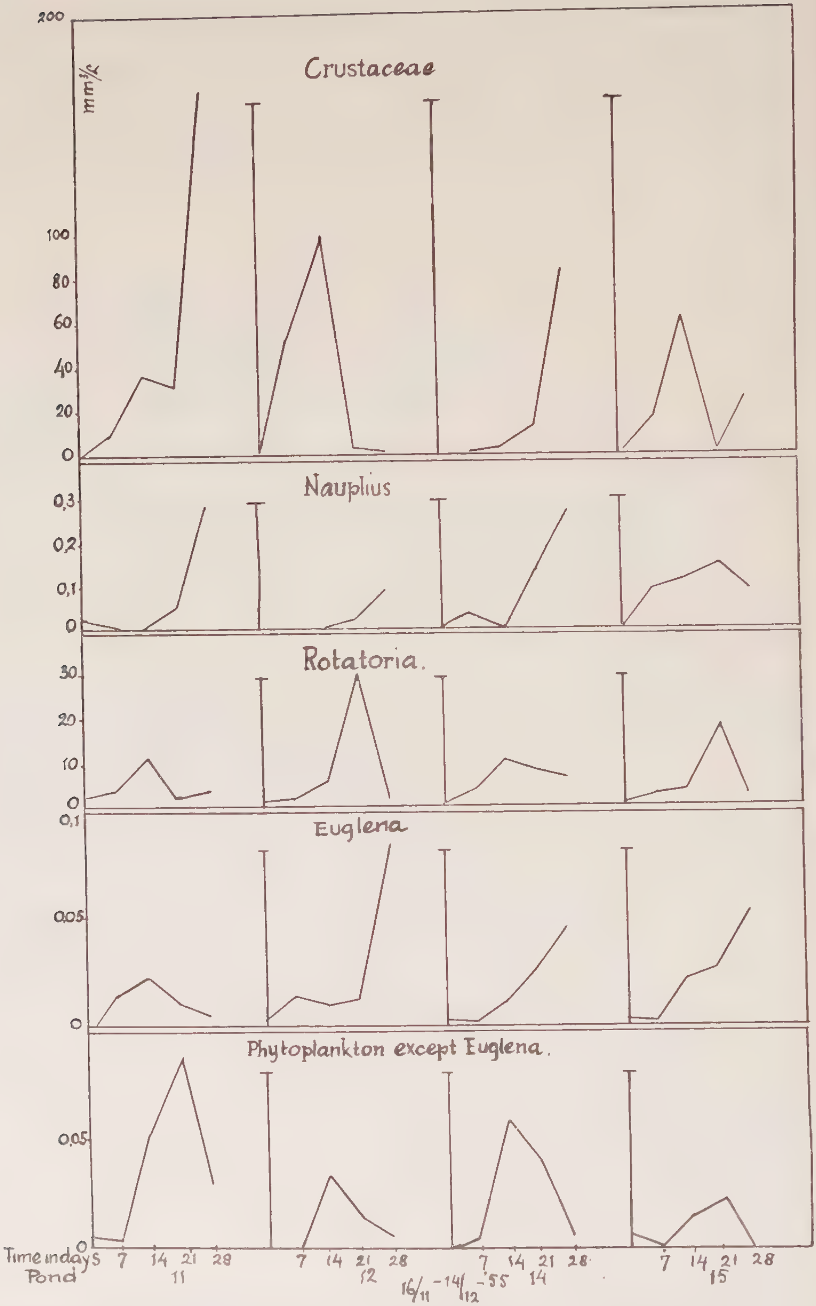

Fig. 12. As Fig .8. Third experiment. Ponds 11 and 14 stocked, ponds 12 and 15 unstocked.

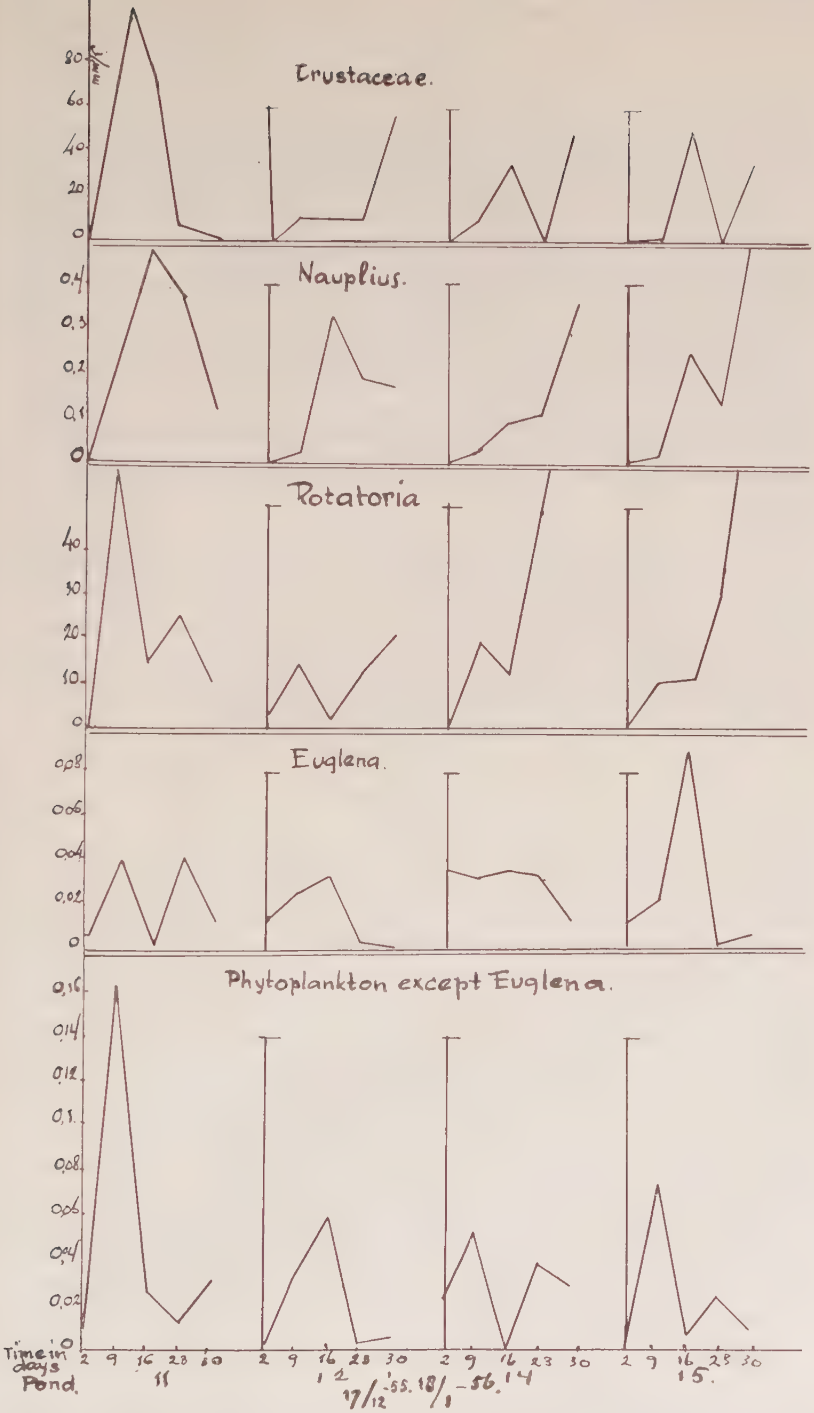

Fig. 13. As Fig. 9. Third experiment. Ponds 11 and 14 stocked, ponds 12 and 15 unstocked.

The above mentioned difference between the stocked and unstocked ponds observed in this experiment might be explained in the following way. In the beginning of the period, when *Euglena* was not yet plentifully developed and other phytoplankters were frequent, conditions were favourable for *Crustaceae*. In the stocked ponds their number was kept rather low by constant grazing of the numerous carp. The metabolism of these fish, accelerating food cycles in the pond, kept conditions favourable for *Crustaceae*. However in the unstocked ponds a situation of overpopulation of *Crustaceae* gradually developed. The amount of phytoplankton — with the exception of *Euglena* — decreased and many *Crustaceae* died. On the dead bodies a large bacterial flora quickly developed, eaten themselves by *Rotatoria*.

Although *Chironomidae* and *Oligochaetae* did not occupy a prominent position in the diet, the number of carp was sufficiently high to decrease their numbers in the bottom of the pond. As in the previous experiment seeds were taken but not to such an extent. Comparison between the food of *Cyprinus* and *Lebistes* once more shows that the main food is practically similar but differences do occur in the various additional components. (table XVIII).

Experiment 4.

20/12 untill 17/1. Ponds 11 and 14 unstocked, ponds 12 and 15 stocked with 1500 carp, total weight 290 gram. Results: pond 12 cropped 956 carp, total weight 750 gram. — increase 460 gram. pond 15 cropped 960 carp, total weight 633.5 gram — increase 313.5 gram.

Data pertaining to this experiment are given in table XIX and figures 14 and 15.

The extremely high value for phytoplankton in 12 after the first week is caused by an outburst of *Eudorina*, immediately followed by *Rotatoria* and *Crustaceae*.

In both stocked ponds the usual bloom of *Melosira* was found in net- and nannoplankton, but owing to the slight volume of the cells the figures do not show this to advantage.

The fact that there is great similarity between both *Crustaceae* and *Rotatoria* in the unstocked pond 14 and the stocked no. 15 goes to show that factors other than those associated with the stocking rate have been active in this case.

Numbers of *Chironomidae* and *Oligochaetae* are distinctly lower in the stocked ponds.

In this experiment heavy losses created a situation of understocking ,as witnessed by the low yields and the constantly rising growth curves. Although *Crustaceae* dominated the food of the carp to a

Table XVIII.

Guts contents of Common carp compared with Lebistes. Ponds 11 and 14. Experiment 3, at 4 dates.

Date	23/11				30/11				7/12				14/12			
Pond	11		14		11		14		11		14		11		14	
Fish	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r
Chironomidae	x				x	x	x	x	x		x		x	x	x	x
other Insects			x				x		x		x		x		x	
Oligochaetae										xx		x				
Crustaceae	xx	x			x		xx		xxx	xx	xxx	xx	xxx	xxx	xxx	xxx
Gastropoda	x		x						x		x		x			
Rotatoria						x			x	x		x				
Diatomeae	x	x	x		x	xx				x	x	x	x			
Euglena						x	x									
Seeds			x						x		x		x		x	

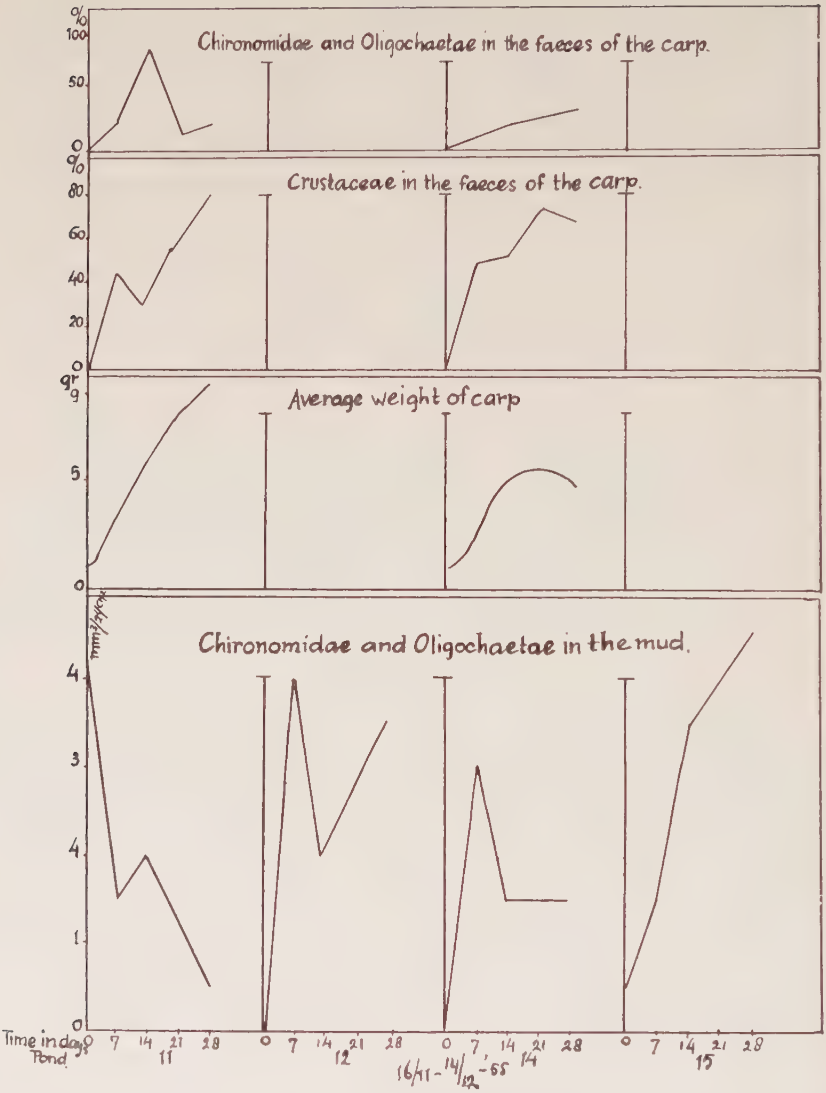

Fig. 14. As Fig. 8. Fourth experiment. Ponds 12 and 15 stocked, ponds 11 and 14 unstocked.

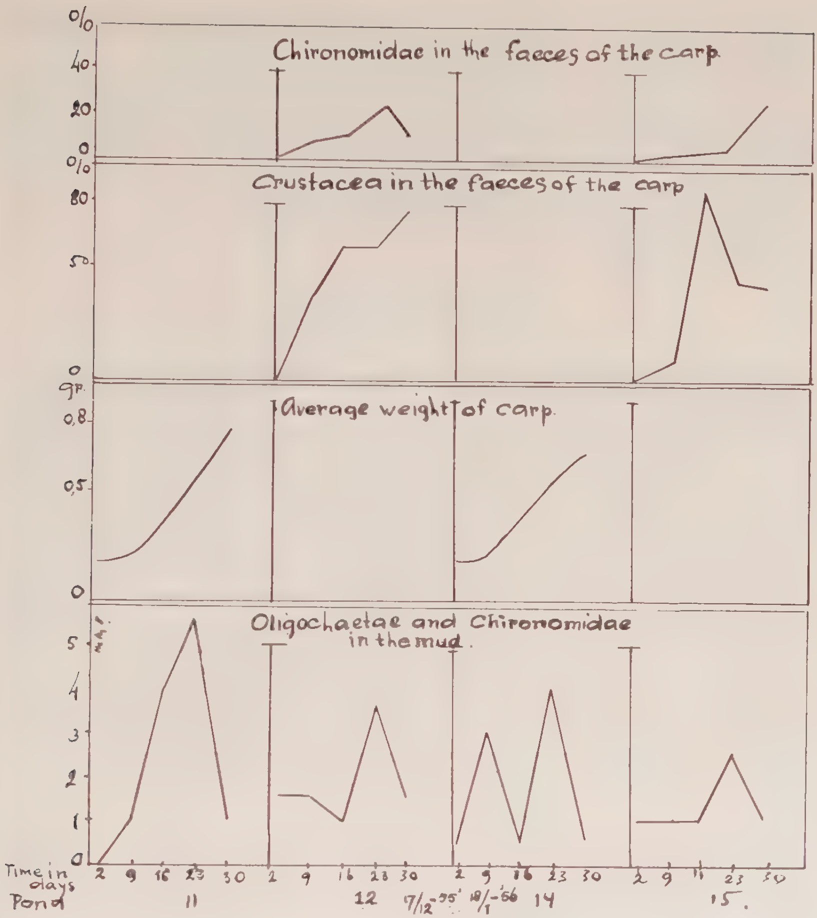

Fig. 15. As Fig. 9, Fourth experiment. Ponds 12 and 15 stocked, ponds 11 and 14 unstocked.

marked extent, no influence of grazing can be found comparing ponds 14 and 15.

As was already stated earlier disturbing influences made results of this experiment unreliable, and hardly any conclusions can be drawn. However, as this experiment was designed to be comparable to the others we do not wish to delete the results.

A comparison between common carp and *Lebistes* confirms previous findings (table XIX).

GENERAL CONCLUSIONS

As in all investigations concerning pond-biota (WIRSZUBSKI 1953, SWINGLE 1947, TANG 1954, VAAS - VAN OVEN, in press and many older authors) great differences between development of plankton in comparable ponds were encountered. Development evidently depends on a multitude of different factors. For this reason we shall use in the following discussions data either comparable for nearly all experiments and for all ponds or for two parrallelles within a single experiment. We feel that conclusions about general processes in the ponds might be drawn from the first and about the influence of the stocked carp from the second category of data.

As the water supply of the ponds does contain a good deal of organic silt but hardly any organisms, plankton will be hardly present in the beginning. Generally speaking an outburst of phytoplankton will be seen during the first weeks, followed by *Rotatoria* and *Crustaceae*.

During the first week *Protococcales* are most important constituents of the plankton, however, disappearing during the following weeks, they are replaced by Diatoms, mainly the genera *Melosira* and *Navicula*. Towards the end of the experiment- after one month- all plankton declines in number, barring certain exceptions. Similarily benthic organisms usually show a maximal development during the second or third week of the period.

We should like to explain these phenomena by developing the following general picture of metabolic relationships and food-cycles in the pond. Immediately after filling with water organic substances on the bottom are being mineralized by bacteria and detritus-feeding animals on the bottom.

Phytoplankton subsists on the minerals released by the above mentioned processes of mineralization. Zooplankton follows the phytoplankton. The detritus-feeders grow quickly and moreover new Chironomid-larvae will develop as a result of oviposition.

During the entire period minerals are being incorporated, either by aminals leaving the pond — those insect larvae reaching maturity

TABLE XIX.

Guts contents of Common carp compared with Lebistes. Ponds 12 and 15. Experiment 4, at 4 dates.

Date	27/21				3/1				10/1				17/1			
Pond	12		15		12		15		12		15		12		15	
Fish	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.	C.c.	L.r.
Chironomidae	x		x		x		x		x		x	x	x		x	
other Insects									x		x					
Crustaceae	xx		xx		xx		xxx	xx	xx	xx	xx	xx	xxx		xx	
Phytoplankton			x										x		x	
Euglena												x				
Closterium	xx		xx						x	x		x				
Spirogyra					x		x		x		x					
Plant tissue					x		x						x			
Seeds					x		x								x	

and flying away —, in carp lost to predating birds, or in organisms not eaten by other pond- biota-, or in a succession of animals with the carp itself at the end.

Benthic fauna is eaten in increasing numbers by animals growing larger all the time. This process of grazing proceeds at a higher rate than the combined processes of growth and new supply by oviposition of *Chironomidae* and growth of aquatic worms. As a result of decreasing availability of minerals phytoplankton must decline.

According to KOSMAROVSKY (1952) *Scenedesmus* needs a higher concentration of phosphates than *Diatomeae*. SMITH & SWINGLE (1939) report a favourable influence of inorganic fertilizer on the development of *Protococcales* but hardly any on *Diatomeae*. Reviewing his findings on the *Diatomeae* of the German Sunda Expedition HUSTEDT (1938) says: „. . . insbesondere erscheint die für die Charakteristik der Gewässer wichtige *Melosira granulata* als eine an den fallenden N- bzw. P- Gehalt gebundene Form".

These statements seem to be in accordance with our observation that *Protococcales* were abundant in the first week of the period and *Diatomeae* — notably *Melosira* — later on.

Considering the influence of the carp we find that usually the development of phytoplankton — and consequently zooplankton too — is encouraged. Even at the end of each period the numbers of phytoplankters found in the stocked ponds were higher than those in the unstocked ones, notably *Melosira*.

However benthic organisms are definitely reduced in number by the fish. The incorporation of minerals does not proceed at a higher rate in stocked ponds than in unstocked ones, although the carp is incorporating a good deal. In order to explain this it might be assumed that more bottom organisms, storing minerals, are eaten by the fish. In unstocked ponds many midge-larvae will be able to accomplish their metamorphosis and will leave the ecosystem bringing about a loss of minerals. Empty skins of pupae were several times encountered on the surface of unstocked ponds and in the stocked ponds hardly any were found.

The numbers of *Crustaceae* and *Chironomidae* encountered in the faeces and in the ponds shown in the figures 8—15, enable us to carry out the following rough calculation.

The *Crustaceae* found in 1 litre form about 1:100,000 part of the total number present in the pond. If we multiply the number for *Chironomidae* with 2, obtaining the number for 16 cm^2, this number will be about 16 : 2000,000 part of the total number on the bottom. As these fractions are about the same we arrive in this way at comparable figures for the numbers of both groups available as natural food for the carp.

In this way an average figure of 37 $\pm$ 6.54 is found for *Crustaceae* and 3. 5 $\pm$ 0.42 for *Chironomidae.*

Similarily the average percentages for all 34 cases found in the faeces are 44.5 $\pm$ 4.7 for *Crustaceae* and 20.8 $\pm$ 3.5 for *Chironomidae.*

As is shown in the figures 8—15 the number of *Crustaceae* eaten depends on the number available but the number of *Chironomidae* eaten does not.

Pending further experimental evidence we wish to explain these relationships by assuming that the carp, taking in *Crustaceae* from the water in an easy way when supply is large, is less inclined to seek food on the bottom or along the shores. In our case the quantity of *Crustaceae* was still insufficient and intensive search for food on the bottom was the result. In experiments published elsewhere (VAAS - VAN OVEN in the press) many cases were found where only *Crustaceae* were eaten when supply was large, although *Chironomidae* were available as well and where *Chironomidae* only formed a large percentage of the guts contents when hardly any *Crustaceae* were present.

SECTION 3.
RELATION BETWEEN GUTS CONTENTS AND AVAILABILITY OF FOOD IN VARIOUS OTHER PONDS.

At this stage we wish to show the results obtained from a study of the intestinal contents of carp of various sizes taken from 2 ponds of the Government Hatchery at Sukabumi and from 4 ponds near Palembang, where pond biota were sampled simultaneously with the guts, in order to compare the results obtained in Bogor with conditions elsewhere in Indonesia. The hatchery at Sukabumi is situated about 60 km South-East of Bogor, at an altitude of 600 m. In the beginning of August, towards the end of the dry season, 30 common carp were collected at intervals of 4 hours, during 24 hours, from pond no 11 and pond no 18, both measuring 504 m^2, and both about 70 cm deep. No 18 never received any manure, no 11 was given horse manure at a rate of 2000 kg/ha during two previous experiments, but none during the growth period when the samples were taken. The hatchery is situated on fertile young vulcanic soil, the water of both ponds showed a pH of 7.8—8.0 in the morning and methylorange alkalinity of 1.1—1.3. The bottom of no 18 was covered with *Spirogyra,* while some *Azolla pinnata* was floating on the surface. In no 11 a heavy growth of *Hydrilla* was noted, with *Azolla* covering about half the surface.

Table XX gives some idea of the production of both ponds, when

stocked with fry or fingerlings of the common carp, together with a few large carp, as is the usual practice in West Java. The data are the results of previous growth periods.

TABLE XX.
Productivity of ponds 11 and 18, Sukabumi.

Stocking rate	Total weight kg	Period in days	Yield in kg 11	18
1) 2500 fry of 2 cm + 7 carp	1.5	25	8,477	8,474
2) 100 fingerl. 5 cm + 6 carp	1.2	36	6,698	7,445
3) 2500 fry of 2 cm + 7 carp	1.5	34	10,860	7,300
4) 75 carp of 7 cm + 3 carp	1.0	36	11,500	10,000
5) 1000 fry of 3 cm + 6 carp	1.0	26	9,030	14,500
6) 2000 fry of 2 cm + 5 carp	0.75	26	10,853	6,650

For the experiment both ponds were stocked on July 17*th* 1954, with 100 fingerlings of 6 gram each — about 5½ cm —. On August 6/7*th*, 5 fish were taken out of both ponds, at 4-hours intervals during 24 hours. These carp were measured, weighed, immediately cut open and the intestinal tracts preserved with 4% formalin. The 30 carp from no. 18 ranged from 10.5 to 14.5 cm in total length and from 24 to 59 grams in weight. Those from no. 11 from 10 to 13.7 cm in length and from 22 to 27 gram weight. During sampling the temperature of the air fluctuated between 20.8° at 4 a.m. and 27.50 at noon, and the temperature of the water — measured at the surface — from 24° at 4 a.m. to 29.5° at 4 p.m.

Samples of net plankton were taken as well as nannoplankton samples, the latter with the Iodine-sedimentation method. Samples of *Hydrilla*, *Spirogyra* and grasses along the banks were washed in large white dishes. All organisms were picked off, studied and counted under a binocular microscope. Identification was undertaken as far as possible and practical for a study requiring a large number of samples.

In 2 cases the guts were damaged, in 5 cases they were found empty, so that the total number studied amounts to 26 from no. 11 plus 27 from no 18, making an aggregate of 53 carp.

Guts contents were studied in the way described in the previous sections, but in this case each quarter of the intestine was studied separately. In this way a better insight into digestibility is obtained.

The availability of natural food in open water, as revealed by a study of net and nannoplankton samples from both ponds, is shown in Table XXI. As only a limited number of samples was available organisms were not counted.

TABLE XXI

Net plankton and nannoplankton in ponds 11 and 18 at Sukabumi.

Organisms	Ponds 11	Ponds 18
Diaphanosoma	xx	xx
Cyclopidae	xx	xxx
Nauplii	xxx	xxx
Filinia	xx	xx
Brachionus	x	xx
Arcella	x	x
Vorticella	xx	x
Synedra	xxx	xxx
Surirella	xx	x
Other Diatoms	x	xx
Oedogonium	x	xxx
Raphidium	xx	xx
Cosmarium	x	x
Staurastrum	x	
Pediastrum	x	x
Richteriella	x	x
Pandorina	x	x
Chlamydomonas	x	x
Euglena	x	x

TABLE XXII.

Organisms in the mud of ponds 11 and 18 Sukabumi.

No sample	Pond 11	Pond 18	
1 (6.a.m.)	2 small snails	Chironomidae	3
		small snails	3
		Diatoms	
2 (noon)	empty	Ceratopogon larvae	1
		Tanypine larvae	3
		Chironominae	2
		small snails	2
3 (6.p.m.)	many Branchiura sowerbyi Bedd.	some Limnodrilus hoffmeisteri Clap.	
	many Limnodrilus hoffmeisteri Clap.	some Branchiura sowerbyi Bedd.	
	many Aulodrilus spec.	small snails	
	many Branchiodrilus hortensis (St.)		
4 (12 mid-night)	many Branchiodrilus hortensis (St.)	small snails	
	some Limnodrilus hoff-meisteri Clap.	Chironomidae larvae	
	some Nais spec.	many Limnodrilus	
		many Branchiura	

As was to be expected hardly any difference between the two ponds could be found, both showing a fairly rich plankton dominated by *Diatomeae* and *Crustaceae*, with slightly more *Oedogonium* in 18 than in 11.

From pond 11 two samples of the aquatic vegetation were taken. In 10.6 gram air-dried *Hydrilla* the following organisms were found:

96 Tanytarsus larvae
3 Chironomidae larvae
1 unidentifiable Tendipedidae.

In the same sample we counted 381 *Oligochaetae.* 66 of these worms were specified as follows:

Dero spec.	51
Nais communis Piq.	8
Naidium spec.	1
Nais paraguayensis M.	1
unidentifiable	5
	66

On 4.6 gram air-dried *Spirogyra* were found:

Caenis larvae, 8 mm	1
Helocharis larvae, 7 mm	1
Tendipes plumosus, $2\frac{1}{2}$ mm^3	1
unident. Tendipedidae	2
	5

The *Hydrilla* was densely overgrown with small *Diatomeae*, young threads of *Spirogyra* and *Oedogonium*. Between the periphyton many *Pediastrum* and *Cosmarium* were found and some *Cypris* spec. *(Ostracoda)*.

On the slimy, slippery threads of *Spirogyra*, mixed with some *Hydrodiction*, periphyton was very rare.

In pond 18, only *Spirogyra* was encountered and the number of organisms found among the threads was far lower. Only 1 *Ceratopogon* larva *(Bezzia*-type) was found, together with 13 *Oligochaetae:*

Dero zeylanica Steph.	5
Dero limosa Leidy	1
Nais paraquayensis M.	3
Nais communis Piq.	1
Nais communis var. caeca Steph.	1
Unident.	2
	13

The bottom samples consisted of approximately 330 cc brown, lateritic mud with some sand and small pebbles. In those from pond 11 many vegetable remains were found. The entire samples were studied under the binocular microscope with the results shown in Table XXII.

The data seem to indicate that *Oligochaetae* bury deeper into the mud at day time and protrude further into the water during the night when the concentration of oxygen is lower.

The supply of natural food for the common carp in both ponds can be summarized as follows. (Table XXIII).

TABLE XXIII.

Supply of natural food in pond 11 *and* 18 *Sukabumi.*

	Pond 11		Pond 18	
Open water	Crustaceae	xx	Crustaceae (Cyclop.)	xxx
Vegetation open water and along the banks	Hydrilla and Spirogyra with Oedogonium and		Spirogyra with Oedogonium and Oligochaetae	x
	Chironomidae	xxx		
	Oligochaetae	xxx		
	Insect larvae	xx		
	Ostracoda	x		
Bottom	Snails	x	Snails	x
Fauna	Oligochaetae	xx	Oligochaetae	xx
			Chironomidae	x
Bottom flora Vegetable detritus	Vegetable detritus	xx	Spirogyra	xx

The guts contents were studied by the methods described in the first section. Each quarter of the intestine was studied separately and the findings were combined later on. Not all of the 4 x 53 protocols can be published here. Some summaries and some instructive instances will have to suffice.

By studying the difference between each of the four quarters of the same intestinal tract it was found that sometimes marked discrepancies occurred between the guts contents of fully comparable carps feeding together in the same pond at the same time, as well as between the fractions of the same intestinal tract. We shall confine ourselves to the data given in Table XXIV, showing the results of the analysis of the guts contents of carp no 4 and no 5 from pond 11, taken at noon.

Consequently carp no 4 took about 7 times as many *Chironomidae* and about 4 times as many insects as no 5, but for *Cyclopidae*,

Table XXIV.

Difference in guts contents of two similar carp, feeding together in pond 11, *sampled at* 12 *hrs*. 00.
(*Figures show numbers of organism, unless volume in mm³ is indicated*).

Pond 11. Carp No. 4. Length 11.5 cm. weight 34 g.

	1/4	2/4	3/4	4/4	Total	Vol mm³
Chironomidae	108	160	54	108	430	130
Ceratopogonidae	4	—	6	—	10	1
Other Insects	12	25	6	13	56	56
Oligochaetae	28	30	2	9	69	7
Cyclopidae	24	40	14	63	141	14
Cladocera	8	5	6	9	28	1.5
Ostracoda	—	—	—	9	9	—
Thread Algae	132	350	122	81	685	13
Plant tissue (in mm³)	3.5	3.5	3.5	3.5	15	15
					Total volume	237.5

Pond 11. Carp No. 5 Lenght 12.5 cm. weight 40 g.

	1/4	2/4	3/4	4/4	Total	Vol mm⁴
Chironomidae	6	7	4	42	59	18
Ceratopogonidae	1	—	—	—	—	—
Other Insects	1	2	12	—	15	15
Oligochaetae	3	2	4	6	15	1.5
Cyclopidae	99	280	332	438	1149	115
Cladocera	30	160	132	150	480	24
Ostracoda	59	358	342	252	1001	50
Thread Algae	50	101	—	60	15	4
Plant tissue (in mm³)	3.5	3.5	3.5	3.5	211	15
					Total volume	242.5

Cladocera and *Ostracoda* respectively the ratio amounted to 7 to 17 times and over 100 times less. Differences between individual quarters of the same guts appear with respect to *Ostracoda* and *Oligochaetae* in carp no 4 and with respect to *Cladocera*, *Ostracoda* and *Thread Algae* in carp no 5.

As in the previous experiment the common carp was found to be an opportunistic, polyphagous feeder, browsing in the mud on the bottom at one moment and — suddenly swimming away — perhaps at the next moment starting to feed voraciously on a swarm of *Crustaceae* encountered in the open water.[1]) This makes the use of large numbers of samples necessary, and for this reason sums of the contents of 10 carp were used in the first Section.

[1]) after many years of study Willer sighed in 1924 „. . . . dass im einzelnen der Karpfen eigentlich in jeder Teichwirtschaft etwas anderes frisst."

TABLE XXV.

Diet of 53 common carp in 2 ponds at Sukabumi, in terms of frequency. Length of the fish 10—14.5 cm.

	Pond 11						Total	Pond 18						Total	Total 11+18
Chironomidae	4	5	5	5	5	2	26	3	5	4	5	5	5	27	53
Other Insects	4	5	5	5	5	2	26	2	4	4	5	5	5	26	52
Oligochaetae	4	5	5	5	5	2	26	3	5	4	4	5	5	26	52
Cyclopidae	4	5	5	5	5	2	26	3	5	4	4	5	5	26	52
Cladocera	4	5	5	5	5	2	26	3	5	3	5	5	5	26	52
Ostracoda	2	5	5	5	5	2	24	2	3	1	2	4	2	14	38
Thread Algae	4	5	5	5	5	2	26	3	5	4	5	5	5	27	53
Plant tissue	4	5	5	5	5	2	26	3	5	4	5	5	5	27	53
Number of carp	4	5	5	5	5	2	26	3	5	4	5	5	5	27	53
Time of sampling	24	20	16	12	8	4		24	20	16	12	8	4		

TABLE XXVI.

Diet of 53 common carp in 2 ponds at Sukabumi, in terms of relative importance.

	Pond 11						Total	Pond 18						Total	Total 11+18
Chironomidae	3+1	3+2	3+1	4+0	3+2	2+0	18+6	0+2	5+0	2+1	4+1	4+1	1+3	16+8	34+14
Other Insects	0+2	2+2	1+3	0+3	2+1	0+2	5+13		0+1	1+0		0+2	0+1	1+4	6+17
Oligochaetae															
Cyclopidae	1+1	0+1	0+1	1+0	0+2	—	2+5	2+1	0+4	1+1	1+4	1+2	4+1	9+13	11+18
Cladocera															
Ostracoda	—	—	1+0	0+1	—	—	1+1	—	—	—	—	—	—	—	—
Plant tissue	—	—	—	0+1	—	—	0+1	1+0	—	0+2	—	—	—	1+2	1+3
Number of carp	4	5	5	5	5	2	26	3	5	4	5	5	5	27	53
Time of sampling	24	20	16	12	8	4		24	20	16	12	8	4		

TABLE XXVII.

Diet of 53 common carp in 2 ponds at Sukabumi, in terms of Volume in mm³.

	Pond 11						Total mm³
Chironomidae	248	270	280.5	424.5	252	130.5	1605
Other Insects	117	215	258	153	204	107	1054
Oligochaetae	21	28.5	54	29.5	25.5	17	175.5
Cyclopidae	86.5	78	171.5	189	141	76	742
Cladocera	15	11.5	29	33	56.5	26	171
Ostracoda	1	4	62.5	61.5	4.5	7	140.5
Thread Algae	27.5	33	38	24	29	9	160.5
Plant tissue	60	75	75	75	75	30	390
Number of carp	4	5	5	5	5	2	26
Time of sampling	24	20	16	12	8	4	

	Pond 18						Total mm³
Chironomidae	63	477.5	190	388.5	673.5	289	2031.5
Other Insects	36	67	102	72	258	149	684
Oligochaetae	7.5	50	15.5	11.	46.5	32.5	163
Cyclopidae	127	216	209.5	355	357.5	588.5	1853.5
Cladocera	1.5	6.5	5.5	26.5	8.5	22.5	71
Ostracoda	—	0.5	0.5	1.5	—	—	2.5
Thread Algae	1.0	13	9.5	6	13	6	48.5
Plant tissue	90	75	105	75	75	75	495
Number of carp	3	5	4	5	5	5	27
Time of sampling	24	20	16	12	8	4	

TABLE XXVIII

Diet of 53 common carp in 2 ponds at Sukabumi, in terms of Volume in percentage.

	Pond 11						Average
Chironomidae	43	37.8	29	43	32	32.6	36.2
Other Insects	20.7	30	26.7	15.5	26	26.7	24.3
Oligochaetae	3.6	4	5.5	3	3.3	4.2	3.9
Cyclopidae	15	10.9	17.7	19	18	19	16.6
Cladocera	2.6	1.6	3	3.3	7.2	6.5	4
Ostracoda	—	0.5	6.5	6.2	0.6	1.7	2.6
Thread Algae	4.7	4.5	3.9	2.4	3.7	2.2	3.5
Plant tissue	10.4	10.5	7.8	7.6	9.5	7.5	8.9
Number of carp	4	5	5	5	5	2	26
Time of sampling	24	20	16	12	8	4	

	Pond 18						Average
Chironomidae	19.3	52.8	29.3	38.1	47	·25	35.3
Other Insects	11	7.4	16	8.1	18	12.8	12.2
Oligochaetae	2.3	5.5	2.4	1.2	3.2	2.8	2.9
Cyclopidae	39	23.9	33.4	40.2	25	50.5	35.3
Cladocera	0.5	0.7	0.9	3	0.6	1.9	1.3
Ostracoda	—	—	—	—	—	—	—
Thread Algae	0.3	1.4	1.5	0.7	0.9	0.5	0.9
Plant tissue	27.6	8.3	16.5	8.5	5.2	6.4	12.1
Number of carp	3	5	4	5	5	5	27
Time of sampling	24	20	16	12	8	4	

In the above tables no. XXV, XXVI, XXVII, and XXVIII, the composition of the guts contents is shown in terms of frequency, relative importance, volume in mm^3 and volume in percentages, as was indicated previously.

Dealing now with larger carp from a different environment we had to make a slightly different classification of the biota.

These tables show that the carp feeds on: *Chironomidae*, *Crustaceae* — mainly *Cyclopidae* —, Insect larvae other than *Chironomidae*, and vegetable detritus, in the order mentioned.

In table XXIX the differences between the guts contents of carp from each pond, judged by the three criteria used, is summarized.

TABLE XXIX.

Differences between the guts contents of carp from 2 ponds at Sukabumi.

Criterium	Pond 11	Pond 18
Frequency	more Ostracoda	
Rel. Importance	more Insects more Ostracoda	more Cyclopidae more vegetable detritus
Volume	more Insects more Ostracoda more Thread Algae	more Cyclopidae

If we revert to Table XXIII, giving the food supply in both ponds, we find that:

1. Although the higher aquatic vegetation in no. 11 contained much more *Chironomidae* than the scanty vegetation in no. 18, these larvae were ingested in comparable numbers in both cases and the greater supply in pond 11 is not reflected in the content of the guts, probably because other insects and larvae were abundant.
2. *Crustaceae* from the open water formed a most important source of food. The larger supply of *Cyclopidae* in pond 18 and of

Ostracoda in no 11, is clearly reflected in the guts contents, as well as the greater supply of *Crustaceae* as a whole in pond 18. The percentages found were: pond 11 = 23.2 % and pond 18 = 36.6 %. As was stated earlier *Crustaceae* in Indonesian ponds were found to show a slight nocturnal movement towards the surface. However no reliable differences could be found in the total volumes of *Crustaceae* sampled an intervals of 4 hours during 24 hours in either pond, probably because the carp takes the *Crustaceae* in all strata of the water.

3. The greater abundance of aquatic insects in no 11 resulted in a greater utilization of this food. In both ponds this source of food was more plentiful than in Bogor and therefore more drawn upon.
4. The large supply of vegetable food originating from the plentiful aquatic vegetation in ponds 11 was used by the carp. Such food was almost absent from pond 18.
5. Although more thread algae were available in pond 18, the carp did not draw on this source to any greater extent than in the other pond, which shows that this food is not taken by preference.
6. The greater abundance of *Oligochaetae* in no 11 was not reflected in the guts contents, neither could any difference be observed between the ingestion of these worms during the night and during the day, although there did seem to be a difference as far as the mud samples were concerned.

   We therefore come to the conclusion that the diet of the common carp is dictated here to a marked extent by the local supply of food, except with respect to *Crustaceae* which are taken by preference and Thread Algae which are avoided.

The samples from Palembang (South Sumatra) originated from 4 different ponds.

Relevant data on these ponds will be found in Table XXX.

In table XXXI, XXXII and XXXIII a survey is given of the supply of natural food occurring in the open water — net and nannoplankton samples — in the mud on the bottom and among the vegetation along the bunds, together with organisms among the roots of floating masses of *Eichhhornia* in these ponds.

In the table XXXIV the results are shown of an analysis of the guts contents of 18 carp from these ponds. In accordance with the more varied diet natural food was grouped in a more specified way. By means of one or two crosses the abundance of organisms not attaining a total volume of 0.5 mm^3 in the total contents of all carp of the samples were shown. The tables were limited to total volume in mm^3 in all carp combined.

Studying the figures of table XXXIV it should not be forgotten that the total number of guts examined was not the same for each

Table XXX.

Data on 4 ponds at Palembang, where guts contents of common carp were studied.

Name of Pond.	Pulau Panggang	Pagar Alam 3	Gunung Kaja	Sungai Selintjah
Surface in m^2	50	700	750	1444
Altitude in m	825	700	715	Sea
Depth of the water in cm	40	80	70	80
Depth of mud layer in cm	15	50	50 (black)	50 (grey)
pH at noon	6—7	7	8—9	5
Methylorange alkalinity	1	1	1	0.6
Aquatic vegetation	absent	some Spirogyra	well developed, Najas, Potamogeton, Spirogyra	abundant, Hydrilla, Eichhornia, Monochoria,
Shore vegetation	Panicum	Panicum	absent	absent
Surface film on the water	Euglena, thick	absent	absent	slight film of Euglena acus Ehrb. E. gracilis Kl. and E. spirogyra Ehrb.
Water supply	from village, muddy	from rice-fields, muddy	from village	from village unfertile
Manuring	faeces	absent	kitchen waste	absent
Total length of carp in cm	± 25	± 7½	± 4	± 16
Number of samples of carp.	2	4	8	4

TABLE XXXI

Composition of net- and nannoplankton in 4 ponds near Palembang.

	Pulau Panggang	Pagar Alam 3	Gunung Kaja	Sungai Selintjah
Phacus	x			
Euglena	xxx	x		xxx
Peridinium			xxx	
Oscillatoria				xx
Chroococcus	xxx			
Pediastrum	x			
Scenedesmus	xx			x
Diatomeae	xx	x	x	xx
Branchionus	xx		xx	x
Triarthra	xx		x	x
Cyclopidae	x	xx	xx	x
Cyclestheria hislopi (Baird)				
Total volume in mm^3/litre	12	0,1	2	0.3

TABLE XXXII

Organisms in the mud layer of 4 ponds near Palembang. Expressed in numbers or in abundance, when not counted.

	Pulau Panggang	Pagar Alam 3	Gunung Kaja	Sungai Selintjah
Diptera larvae				
Chironomidae (plumosus type)	1	1		
Tanypidae		4		
Ceratopogonidae (Bezzia type)		4		
Oligochaetae				
Dero limosa	4			
Limnodrilus hoffmeisteri	6	4		
small Snails		3		
Algae				
Spirogyra		xx		
Diatomeae		xx		
Lyngbya maior Men.			thick layer	
Vegetable detritus	xx	xx	xxx	xxx
Volume of mud sample in mm^3.	50	85	60	70

Table XXXIII.

Flora and fauna among shore vegetation and among the roots of floating Eichhornia in 4 ponds near Palembang.
Expressed in numbers or in abundance when not counted.

	Pulau Panggang	Pagar Alam 3	Gunung Kaja	Sungai Selintjah	
				Among veget.	Among Eich. hornia
Chironomidae	920	12			
egg-clusters of Ch.	xxx				
Tanypidae		2			
Paratanytarsus			1	73	9
Tabanidae				2	
Dero limosa	2			2	4
Limnodrilus hoffmeisteri	3	8			
Branchiura sowerbyi		1			
Aulophorus furcatus		1		24	
Aulodrilus kashi St.				12	
Naidium sp.				5	1
Nais paraguayensis v. aequalis				4	7
Nais paraguayensis				13	24
Nais pectinata				3	
Nais sp.				5	
Pristina proboscidea					11
Pristina longiseta				1	
unidentified remains				3	
Sphaerodema rustica (Fab.)	3				
Ranatra elongata Fab.	1				
Micronecta quadristrigata Bred.	1				
Microvelia spp.	3				
Procloeon bifidum larva	7				
Heloechares larva	3				1
Ephemeridae larva			2		6
Nematoda	xx				
Ostracoda	xx	x			
Cyclopidae	xx				
Cyclestheria hislopi				15	114
Diatomeae	xx	x	x	x	
Peridineum			x		
Euglena	xxx			x	
Desmidiaceae		x	x		
Green thread algae	x	xx			
Lyngbya *M*			xxx		
Protozoa	xx				
Volume of sample	11.8 gram grass 13 ccm mud	15 gram plants 2 cc mud	8 gram plants 20 cc mud	3 gram plants	11 gr Eichh

TABLE XXXIV.

Guts contents of 18 carp from 4 ponds near Palembang. Total volumes in mm^3 *for all fish of the sample. Crosses used for items with lower volume than 0.5* mm^3.

	Pulau Panggang	Pagar Alam 3	Gunung Kaja	Sungai Selintjah
Chironomidae	780	12	103	134
Ceratopogonidae	0.6			
Odonata lar.	2			
other Insects lar.		23	14	43
Oligochaetae	301	x	1	70
Cyclopidae	40	57	13.5	203
Ostracoda	x	x		26
Cyclestheria	0.6			107
Cladocera		27	3	
Rotatoria			x	x
Euglena	xx			x
Phacus	xx			
Diatomeae	xxx		xx	xx
Closterium			x	x
Lyngbya	xx		xx	
Spirogyra	x	9	0.6	
Plant tissue	65	5	52	350
Length of carp in cm	30	7.5	3—5	14—18
Number of carp	2	4	8	4

pond and that the carps differed in seize, as indicated in the table. In the guts of the fish from Pagar Alam 3 we recognized *Veliidae* and *Corixidae* among the remains of insects, *Diaphanosoma* and *Mesocyclops* among the *Cyclopidae* and *Bosmina* among the *Cladocera*. Among those from Sungai Selintjah adult *Veliidae*, *Corixidae*, ants and larvae of *Hydrophilidae* among insects, and *Aulodrilus Limnodrilus*, *Aulophorus* and *Nais paraguayensis* among the worms by means of the chetae.

Table XXXV contains a summary of the food supply and its utilization in these four ponds.

From the data contained in this table we can draw the following conclusions:

1. Plant tissue — vegetable detritus-, although plentiful even in the ponds with scanty vegetation, was never ingested in equivalent quantities, the carp giving preference to other kinds of food.
2. Thread algae were only encountered in the guts of carp from ponds in which *Spirogyra* or *Lyngbya* were abundant, but in small quantities compared with the supply.
3. Insect larvae and worms from the bottom and *Crustaceae* from the open water and among the littoral vegetation were taken by the carp in quantities in accordance with local availability.

Table XXXV.

Food supply and utilization in 4 ponds near Palembang.

Pond	Utilization of food		Supply of food
Pulau Panggang.	Chironomidae	+++	+++
small pond	Oligochaetae	++	+
big carp 30 cm.	Cyclopidae	+	+
little open	Plant tissue	+	+++
water.			
Pagar Alam 3.	Chironomidae	+	+
large pond	Other Insects	+	+
carp 7 to 8 cm.	Cyclopidae	+	+
plenty open	Cladocera	+	+
water	Spirogyra	+	+++
	Plant tissue	+	+++
Gunung Kaja.	Chironomidae	++	+
large pond.	Other Insects	+	+
small carp,	Cyclopidae	+	+
4 cm.	Cladocera	+	+
plenty open	Plant tissue	++	+++
water			
S. Selintjah	Chironomidae	++	+++
very large	Other Insects	+	+
pond.	Oligochaetae	++	+++
carp 16 cm	Cyclopidae	++	+
plenty of	Cyclestheria	++	++
vegetation	Ostracoda	+	+
	Plant tissue	++ -	— —

SECTION 4.

RELATION BETWEEN GUTS CONTENTS AND AVAILABILITY OF NATURAL FOOD IN A SEWAGE POND AT BODJONG LOA, BANDUNG.

SITUATION AND EXPLOITATION OF THE POND

Near the southern border of the city of Bandung, the capital of West Java, 373 fresh water fish ponds are found, measuring together 182.5 ha, situated at an altitude of 750 m above sea-level.

This area, known as Bodjong Loa, is famous for its high yields of fish — from 2000 to 5000 kg/ha/year — a result of the combination of fertile soil, most fertile water from the sewers of the town, and suitable methods of cultivation.

The ponds are shallow, measuring 10—30 cm at the inlet, against 40—60 cm at the outlet. Mud accumulates rapidly on the bottom and has to be removed every 3 or 4 month. The ponds are stocked with a mixture of either 60 % or 70 % *Tilapia mossambica*, 20 % or 10 %

Cyprinus carpio and 20 % *Helostoma temmincki*, or 80 % *Tilapia* and 20 % *Cyprinus* by weight.

The fish are stocked at a length of 5—8 cm and at a rate of 100—150 kg/ha for rearing ponds and cropped after 1 month at a weight of 20—30 gram. Cropping takes place 10 times a year, 2 months being used for improvement and maintenance of the ponds. During the rainy season when water is plentiful cropping is carried out by means of total draining, during the dry season water is sometimes scarce and the fish are gathered with screens. Some ponds are used as nursery ponds.

The pond investigated was a rearing pond of 5600 m^2, in front of the residence of the prominent pond owner Hadji KOSASIH, who kindly gave us numerous facilities throughout the work on the spot.

This pond was partly drained, cropped with screens and restocked with 20 kg *Helostoma* of 6 cm, 10 kg common carp of 7—10 cm and 70 kg mudjair of 6 cm, every month and completely drained and overhauled every 4 months.

Only the amount of water leaving the pond at the outlet could be measured with some degree of accuracy, but the amounts leaving by seepage and evaporation as well as the amount entering the inlet could only be guessed. We obtained the impression that the pond is completely replenished with water within one month.

HIGHER VEGETATION

Allong the shallow parts of the shores a higher vegetation is found of *Althernanthera*, *Calocasia*, *Polypodium*, *Jussicua* and grasses.

Floating on the water are *Pistia stratiotes* L. and *Limnobium stoloniferum* (G. M. GRIS).

AQUATIC VEFETATION

No rooted aquatic vegetation is present. The water shows a greenish colour and the surface is covered with patches of *Euglena* spp, the red species *sanguinea* and *heamatococcus* as well as the green ones *Ehrenbergi*, *acus* and others. Together with *Cyanophyceae* they often form a scum on the surface.

In July 1954 12 plankton samples were taken by HASANUDDIN SAANIN at intervals of 2 hours during a period of 24 hours. In October 1956 the author took several samples of net — and nanno-plankton. The result of the microscopic examination of these samples is given in table XXXVI.

Besides these organisms the water contains many bacteria. Forms of the *Sarcina*-type and the *Spirillum*-type were most abundant. Some *Hydrarachnidae* were observed and some eggs of

TABLE XXXVI.

Net and Nannoplankton of the pond at Bodjong Loa (M = „en masse").

Protozoa		*Chloromonadineae*	
Homotrichous Ciliates	xx	Euglena	M
Heterotrichous Ciliates	xx	Trachelomonas	x
Thecamoeba	x	Phacus	xxx
		Chlamydomonas	x
Vermes		*Chlorococcales*	
Nematodes	x	Scenedesmus	xx
		Ankistrodesmus	x
		Raphidium	x
		Crucigenia	x
		Tetragenia	x
Rotatoria		*Volvocales*	
Branchionus	M	Pandorina	x
Filinia	xxx		
Rotifer	xxx	*Oedogoniales*	
Pedalion	xxx	Oedogonium	xx
		Conjugales	
		Spirogyra	xx
		Staurastrum	x
		Closterium	x
Crustaceae		*Diatomeae*	xx
Diaphanosoma	x		
Cladocera		*Cyanophyceae*	
Ostracoda	x	Oscillatoria	M
		Lyngbya	xxx

worms living as parasites inside the guts of men such as *Ascaris* and *Trichocephalus*, a result of the inflow of water from sewers of the city.

The guppy, *Lebistes reticulatus*, was most frequent in the pond and was observed in all stages. The tiny fry was so abundant that many plankton samples strained from 12 liter of water were found to contain a dozen young *Lebistes*, mainly at night when the fish are at the surface. Common organisms notably rare were *Notonectidae* and snails.

BOTTOM

The bottom of the pond was covered with a layer of black soft mud full of coarse and fine remains of vegetation, chitinous sceletons of insects and many bones, scales and other parts of the sceleton of small fish. As the inflowing water is full of kitchen-waste and human excreta much of this material will be of allochtonous origin.

Animal life was rare in this layer of mud. Only some *Nematodes*, *Nais*, *Limnodrilus* and *Chaetenotus* and an occasional *Chironomide*, *Ceratopogonide*, *Culicide* and *Muscide* were found on shallow spots, many deeper parts did not show any animal life. Empty shells of *Diatoms* were encountered in small numbers.

Animal life here is in strong contrast with the situation found in the running water of the sewers leading into the pond. The bottom of those sewers is covered in many places with a dense growth of *Oligochaetae* and red *Chironomidae* even to such an extent that these organisms are collected in bulk and sold to owners of aquaria as food for their fish.

HYDROCHEMISTRY

The water of the pond was investigated on the spot in October 1956. Owing to the heavy bloom of small filamentous blue-green algae and the large amount of silt the Secchi disc disappears already at 12 cm. As Bandung is situated in a region rich in lime the Calcium contents of the inland waters is high and in this case the sewage from the city adds to the mineral contents of the water. A methyl orange alcalinity (acid combining capacity) of 4 was found. Other features were examined at various times of the day and night with results given in table XXXVII.

TABLE XXXVII.

Hydrochemical data of the pond.

Time	Temperature air	pH	% O_2	Temperature water	
7.30		7.4	0	24.0	surface
7.30	24	7.6	0	23.5	bottom = 70 cm
8.15			10		surface
8.45		7.7	64	26.0	surface
8.45	26.25	7.6	46	26.0	bottom = 70 cm
12.00		7.7	185	29.0	surface
12.00	28.0	7.4	21	27.0	bottom = 70 cm
18.00		7.5	4	29.5	surface
18.00	25.5	7.1	0	28.2	bottom = 70 cm
22.30		7.6	0	27.5	surface
22.30	23.0	7.0	0	26.2	bottom = 70 cm
4.00		7.0	0	25.0	surface
4.00	21.5	7.0	0	24.8	bottom = 70 cm

DISCUSSION OP THE ENVIRONMENT

The above data enable us to form a picture of the suitability of the environment from the point of view of fishculture.

The inflowing water carries a large amount of particulate and dissolved organic substances and silt. This material covers the bottom with a thick layer and oxygen-absorbing processes of mineralisation will be most active at the high temperature and the high concentration of Calcium.

For this reason the bottom itself and the water near it are devoid of oxygen during a large part of the day and night. During the hours of sunshine the heavy bloom of phytoplankton — mainly small filamentous *Cyanophyceae* 65—75 μ in length — will create a situation of super-saturation at the surface and mixing of the shallow water will carry some oxygen to the lower strata. However, oxygen-absorbing processes predominate to such an extent over assimilation that according to our sampling methods even the surface does not contain any oxygen during part of the early morning and the night. No doubt the uppermost layers of the water, where oxygen from the air is attracted at a rapid rate by the large gradient of diffusion existing between the water and the air, will still contain some oxygen, but with the usual Winkler method, where a sample bottle of 100 cc is used, none could be detected at various times.

The poor oxygenation, the thickness and softness of this layer of mud, together with its rapid accrement are the reasons for the difference between the outburst of animal life on the bottom of the sewers and the paucity on the bottom of the pond. Therefore the bottom does not contain many organisms suitable as food for fish.

In the water enormous numbers of small, filamentous *Cyanophyceae*, *Euglena's*, *Protococcales* and *Rotatoria* are found, but bigger zooplankton is scarce. Thus we may conclude that for filter-feeders food is plentiful but that the usual food for the common carp is scarce.

FOOD OF THE VARIOUS FISHES

1. Lebistes.

Lebistes of all size were seen in large quantities. During the night they come to the surface sucking in the uppermost layer still containing some oxygen. The enormous fecundity of this species is well known. In a gravid female of 43 mm total length, we counted 63 young. Four lots of different size were examined with results shown in table XXXVIII.

2. Tilapia mossambica (Mudjair)

As no segregation of the sexes is practised here Mudjair breeds profusely in the pond and many shoals of young can be seen. Four lots of different size were examined, as shown in table XXXIX.

The digestability of the threads of blue-green algae can be demon-

TABLE XXXVIII.

Guts contents of Lebistes from the pond at Bodjong Loa.

Number	total length in mm.	Contents of the guts.
16	9— 16	Rotatoria frequent. The eggs were only partly digested. Diaphanosoma. Protococcales, partly digested. Cyanophyceae almost undigested. A single Chironomide larva, width of head-capsule 100 μ in a fish of 15 mm. Phacus, partly digested. Euglena idem.
7	18— 22	idem.
6	24— 27	idem. Unidentifiable green detritus. Diatoms.
10	41— 50	idem. Diatoms fairly frequent. Detritus.

strated by a comparison between the microscopic habitus of the threads from the stomach and those from the hindermost part of the guts.

Diatomeae and *Rotatoria* were taken in smaller numbers than was done by the *Lebistes*. Some guts of the bigger fish were not completely filled, some even very sparely.

TABLE XXXIX.

Guts contents of Mudjair from the pond.

Number	total length in mm	Guts contents.
4	15— 22	Cyanophyceae fairly well digested. Single celled green algae partly digested. Diatoms. Rotatoria.
4	26— 34	idem. green detritus.
5	55— 64	idem. idem.
7	100—120	idem. idem. Euglena. Mud.

3. Helostoma temmincki (Tambakan)

Helostoma forms 20 % of the stock. In July 1954 this fish was sampled at intervals of 2 hours during 24 hours by HASANUDDIN SAANIN. The guts contents of about a dozen of these fish was examined, together with that of 2 fish sampled in October 1956. All *Helostoma* measured about 10 cm in length. The guts contained the same organisms as those of *Tilapia*, in addition to smaller single celled green algae such as: *Raphidium*, *Ankistrodesmus*, *Cosmarium*, *Trachelomonas*, all in a stage of partly digestion and some *Merismopedia* almost undigested. Some eggs of pathogenic worms were also encountered demonstrating the rather undiscriminative straining of the plankton.

4. Cyprinus carpio (common carp)

In July 1954 HASANUDDIN SAANIN collected 12 times 10 carp at intervals of 2 hours during a period of 24 hours. The guts of these carp were cut into three sections and after noting the degree of filling of each section the contents were examined. These carp fluctuated in total length from 7 to 12 cm. In October 1956 we collected 8 carp of 6—8 cm and 10 carp of 9—16 cm, which were treated in the same way. In addition to the usual food of the carp we found remains of small fishes in many cases. Scales, vertebrate, part of fins and bones were easily distinguished, remains of muscles not yet totally digested showed a district xanthoprotein reaction with concentrated HNO_3. When sometimes the fish were found in the front part of the guts and therefore still in fairly undigested condition it was easy to identify them as fry of *Tilapia* and *Lebistes*. In one carp of 7 cm no less than 49 Mudjair of 7—10 mm. were encountered immediately behind the gullet.

It followed from an examination of the guts in the described way that 5 carp out of 120 did not show any contents and that the frequency and relative importance I of the various items of food were as shown in table XL.

TABLE XL.

Frequency and relative importance I of various items of natural food in the guts of 120 *carp from the pond at Bodjong Loa, of which* 5 *were empty.*

	Frequency.	Relative Importance I.
Remains of fish	81	45
Insects	79	7
Chironomidae	27	
Oligochaetae	25	1
Crustaceae	15	
Euglena	28	
Cyanophyceae	37	2
Veg. Detritus	111	60
	Total	115

It is seen in the table that the items of natural food usually of most importance — *Crustaceae*, *Chironomidae* and other insect larvae — do not reach their customary level in this special environment, but that the carp must rely on small fry of *Lebistes* and *Tilapia* and vegetable detritus. Inside the guts *Cyclopidae*, *Cladocera*, *Ostracoda*, *Oligochaetae* and *Chironomidae* were far more frequent than in the environment, proving that the carp chased those organisms as much as possible, but their low availability forced the fish to take other food.

In October 1956, 8 carp of 6—8 cm and 10 carp of 9—16 cm in

total length were collected and examined. The results will not be shown in detail as they did not differ from our findings in the fish collected in 1954. Table XLI summarizes the results in terms of frequency and relative importance I of volume.

TABLE XLI

Frequency and relative importance 1 *of items of natural food in the guts of* 8 *carp of* 6—8 *cm and* 10 *carp of* 9—16 *cm in total length, collected in October* 1956

	Frequency	Relative importance
Remains of fish	5	5
Chironomidae	13	3
Other Insects	12	
Oligochaetae	10	
Crustaceae	11	
Euglena	9	
Cyanophyceae	10	
Veg. Detritus	18	10
	Total	18

The carps cultivated in the pond at Bodjong Loa originate from a rearing pond in Tjiateul, a village in the neighbourhood of Bandung. The pond is fed with water from a large irrigation ditch. Some *Hydrilla* grows in the pond. Here a mixture of Common carp, *Puntius javanicus*, *Helostoma* and *Tilapia* is reared in growing periods of 1 month. Nine carp of about 10 cm in length were examined. As no data on food production in the pond could be gathered we examined the guts contents in a cursory way only, with results given in table XLII.

TABLE XLII.

Guts contents of 9 *carp of* 10 *cm total length from the rearing pond at Tjiateul.*

No carp.	1	2	3	4	5	6	7	8	9	Freq.	Rel. Imp.
Remains of fish	—	—	M	—	xxx	—	—	xxx	—	3	3
Chironomidae	xx	x	—	xx	—	—	—	—	—	4	—
Other Insects	xx	—	x	—	—	—	—	—	—	1	—
Oligochaetae	—	—	—	—	x	xx	—	—	—	1	—
Crustaceae	x	xx	—	xxx	xx	xx	xx	x	xxx	8	1
Veg. Detritus	xxx	xxx	—	xxx	xxx	—	xxx	xx	xxx	8	5
											9

Although the usual way of feeding on *Crustaceae*, *Chironomidae*, *Oligochaetae* and aquatic insects is practiced by these carp in a much more pronounced way than at Bodjong Loa, it follows that here too

small fry is taken quite frequently and forms an important part of the food of the carp.

5. Puntius javanicus (tawes)

Finally we wish to draw attention to the results of an examination of the guts of 10 *Puntius javanicus* also from the rearing pond at Tjiateul, grown in combination with the above mentioned carp. Ten fish of about 11 cm in total length were examined. None of the guts were more than half full, 3 were completely empty. The rest was filled with vegetable detritus, *Diatomeae*, *Protococcales* and thread algae, but also — to a slight extent — with *Crustaceae* and insects. One tawes had eaten fry of either *Tilapia* or *Lebistes*. As in the case of the common carp the paucity of the usual type of food — higher aquatic vegetation in this case — forced the fish to eat unusual food.

DISCUSSION

The main aspect of this pond is the heavy supply of allochtonous material from outside. This is the reason that the mudlayer on the bottom is so poorly oxygenated and therefore so sparely populated with animals. Mineralizing processes are most active in this mudlayer, carried out by a dense flora of bacteria. The main organisms eating these bacteria are the *Protozoa* and *Rotatoria*. These form the food of *Lebistes*. The carp does not derive much nourishment from these tiny organisms although they are ingested to a certain extent.

The paucity of its normal food forces the carp to rely on fry of *Tilapia* and *Lebistes*.

As was stated in the survey of the literature, fish and other vertebrate animals can be eaten by the common carp and even cannibalism can be experimentally induced. As the carp feeds voraciously on insects and their larvae in all stages of its life it is small wonder that, incidentally, fish and fry are devoured. NOWAK, KAMPRATH, CRONHEIM, WALTER and others, mentioned by WUNDER (l.c.), state this phenomenon. WUNDER (l.c.) found fry of bass and *Leucaspius* in the guts of full-grown carp, CONTAG (1930) encountered 4 newts, 6—8 cm in length, in the guts of a 27.5 cm long carp, weighing 370 gram. It is interesting to note in this respect that the Dubisch method of spawning as well as the Indonesian method with „kakabans'' both segregate the spawners and the larvae as quickly as possible, in the first method by removing the spawners and in the Indonesian method by removing the fibermattings with the eggs. This is a form of protection of the eggs and larvae from the spawners.

In this special environment the ability of the carp to adjust its

food to such an extent to local availability is the reason why good crops of this fish can be gathered from the pond at all. Organisms as small as *Rotatoria* and *Protozoa* are unimportant for the carp of a size such as grown here, even if they do occur in large numbers, and the same holds for the small single-celled or filamentous algae forming the bulk of the microvegetation in this pond. Zooplankton — *Diaphanosoma*, some *Cladocera* and *Ostracoda* — is sparely developed and the bottom fauna is also quite insufficient for the carp. As links between the *Rotatoria* and *Protozoa* and the carp the fry of *Tilapia* and *Lebistes* fill a niche of great importance from the point of view of production of carp. Under different circumstances *Lebistes* must be seen as a severe competitor for food of the carp. Here too it is eating *Crustaceae* and even an occasional *Chironomida*, but this slight disadvantage is quite overshadowed by the way *Lebistes* concentrates the food present in the form of too small organisms and thus makes it available in an indirect way for the carp. Dealing with an organism as the common carp the milieu is seen to have a decisive influence on relationships between two species of fish living together. The paucity of oxygen on the bottom renders the vast store of organic matter, accumulated on the bottom almost unavailable to most organisms, the extensive bacterial flora being the main agent responsible for its use. Filter-feeding *Rotatoria* and *Protozoa* subsist on these bacteria and thus constitute the next link in the food-chain.

Both *Tilapia* and *Helostoma* are independent from these food-chains, subsisting directly on vegetable micro-organisms and vegetable detritus. Food-chains as we see them in this pond and in the ponds at Bogor are shown in the diagrams, fig. 16 and 17.

GENERAL CONCLUSIONS AND SUMMARY

1. Studying quantitatively the guts contents of 500 carp fry (*Cyprinus carpio* L.) from the moment the mouth and anus were formed until a total length of 135 mm was reached, it was found that:
   a. As in all previous studies large differences were observed between the contents of the guts of comparable carp living together in the same pond and even between the contents of each quarter of the guts of the same fish.
   b. *Cyclopidae*, *Cladocera* and *Ostracoda* formed the most important item, from the beginning throughout the experiment.
   c. Chironomid-larvae were ingested from the first day on and remained most important.
   d. Other aquatic insects and their larvae were eaten in increasing numbers as the fry grew older.

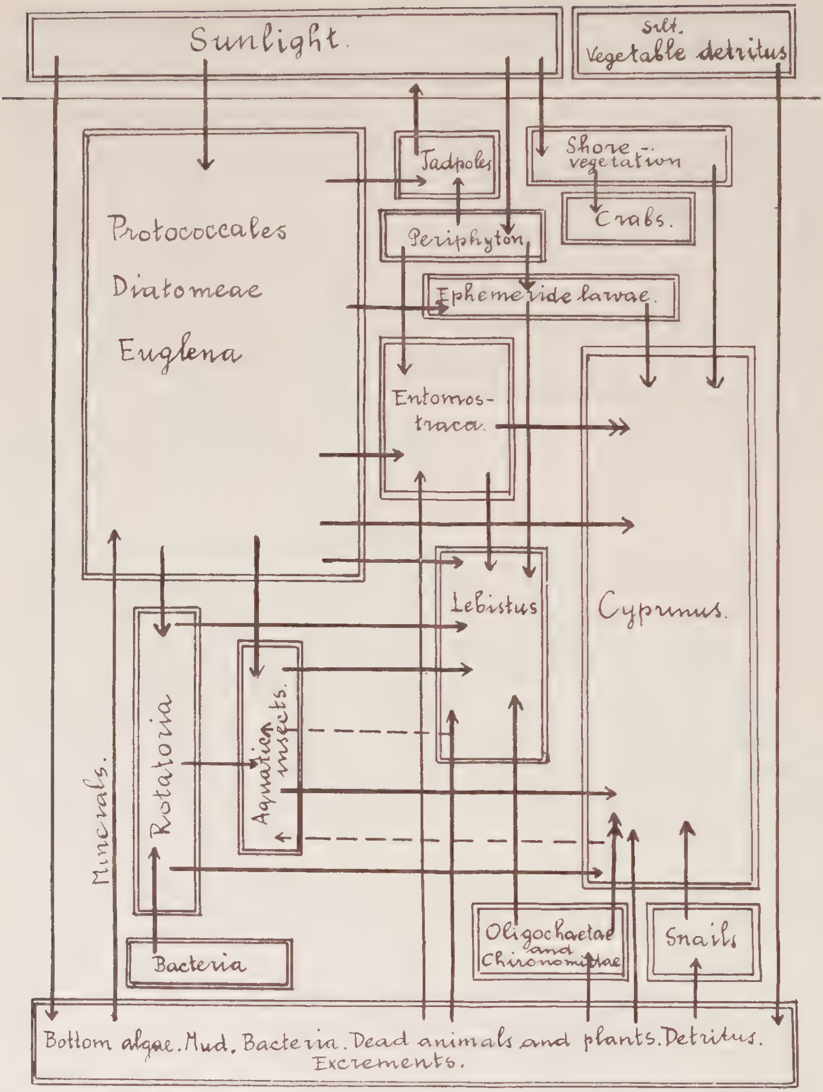

Fig. 16. Schematical representation of food-chains in a carp pond in Bogor (usual type in Indonesia).

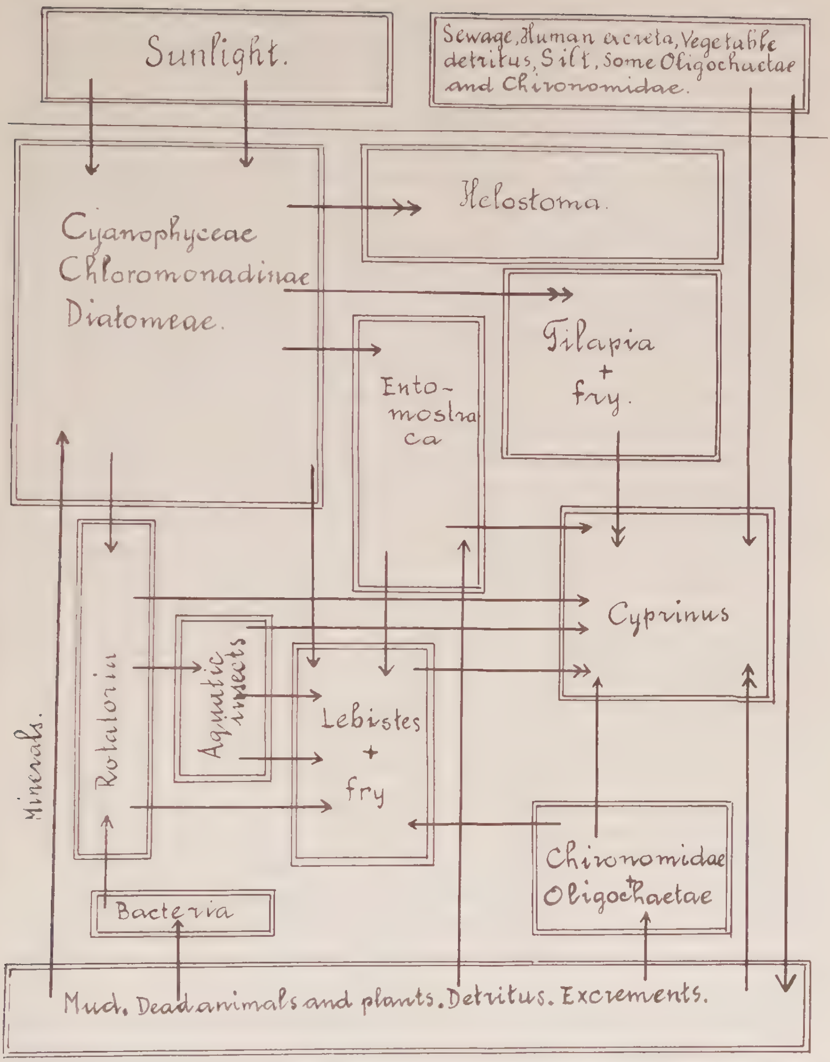

Fig. 17. Schematical representation of food-chains in the sewagepond at Bodjong Loa, Bandung.

e. Under 40 mm in length the fry derives some food from *Closterium*, phytoplankton and *Protozoa*. However many phytoplankton-organisms leave the guts alive.
f. Fry longer than 40 mm eat small snails and also plant tissue and thread algae are ingested and partly digested by the later stages. Plant remains were readily available in the pond from green manure.

2. The length of the body and the guts showed periods of rapid increase in the beginning of each growing period, alternating with slow increase towards the end. After refilling of the pond at the beginning of each period, when growth of the carp was rapid, the ratio between length and height of the body was seen to fall, and the volume of the guts contents was seen to rise. The reverse took place towards the end of each period. This fluctuation in the quantity of food ingested was shown by all groups of natural food, except by vegetable food, of which source a continuously increasing quantity was found in the guts in most cases. In accordance with many published statements these facts might be explained in this way that vegetable food, being readily available in easily digestable form — decaying green manure — is taken by the carp in increasing quantities when other sources became scarce, and that growth is slower when the carp have to depend on this source.
3. In 2 similar pond guts contents of a total of 30 carp were sampled at the end of 4 periods of 1 month. Every week biota in the pond were sampled and studied quantitatively or semi-quantitatively. Some faeces of live carp were studied and the fish weighed. Two other ponds were left unstocked each time. In this case no fodder, nor any kind of manure was given.
   a. The data of the guts contents and faeces confirmed our earlier findings. Vegetable food was less important as no green manure was applied.
   b. Availability of pond biota was studied and compared with the guts contents. Guts of *Lebistes reticulatus*, *Crustaceae*, aquatic insects and other biota were studied so as to obtain a picture of food-chains in stocked and unstocked ponds.
   c. All organisms of importance as natural food for the carp proved to be readily available. The large supply of *Diatomeae*, *Protococcales* and *Euglena* was not touched by the carp. Among the *Desmidiaceae* the large *Closterium* is ingested.
   d. Comparing the diet of *Lebistes* with that of the common carp it was found that in these ponds the diets are nearly the same when supply is plentiful, however, when *Crustaceae* and *Chironomidae* are scarce *Lebistes* turns to *Cyanophyceae*, *Ro-*

tatoria and *Nauplii* and the carp rather to detritus, small snails and benthic algae.

c. As in all investigations concerning the development of pond biota large differences between different organisms were encountered under comparable conditions. In the first weeks usually phytoplankton grows rapidly followed by *Rotatoria* and *Crustaceae*. *Melosira* and other Diatoms become abundant towards the middle of the period. All plankton declines in number towards the end. Benthic organisms also show a maximal development during the second and third week. The influence of the carp on the other biota was found to be an encouragement of phytoplankton and a reduction in the numbers of benthic forms.

   A theory — discussed in greater detail by the second author elsewhere — is mentioned which regards the incorporation of minerals available in the water filling the pond, as the principal limiting factor for development of pond biota. A rough quantitative comparison of the numbers of *Crustaceae* and *Chironomidae* in the guts and in the pond gave an indication that relatively more *Chironomidae* had been eaten in this case.

4. The guts of 53 carp from 2 ponds near Sukabumi and of 18 carp from 4 ponds near Palembang were studied and compared with the supply of pond biota. In the case of the Sukabumi ponds the fish were sampled 6 times at regular intervals during 24 hours in order to account for eventual differences in availability of *Crustaceae* owing to diurnal fluctuations.

   a. Comparing both Sukabumi ponds it was found that a greater supply of *Crustaceae*, aquatic insects and vegetable food was correlated with a greater utilization by the carp, however for *Chironomidae* and *Oligochaetae* a similar relationship was not found.

   b. Comparing the Palembang ponds it was found that large supplies of plant tissue and thread algae were not utilized to a marked extent.

      Crustaceae from the open water and among the shore vegetation and insects larvae and worms from the bottom were ingested in accordance with local availability.

5. A sewage pond at Bodjong Loa, where common carp is cultivated in combination with *Helostoma* and *Tilapia*, was investigated.

   Oxygen contents of the water at the surface fluctuated from heavy super-saturation during the day to absence at night. The bottom — covered with a thick layer of mud and vegetable detritus of allochtonous origin — was devoid of oxygen, but for a short period at noon.

Aquatic vegetation consisted of a large bacterial flora, a heavy bloom of *Euglena* and small filamentous *Cyanophyceae*. Zooplankton was scarce. Only at some shallow spots some *Chironomidae* and *Oligochaetae* were found on the bottom, *Rotatoria* — feeding on the dense bacterial flora — were abundant.

In the diet of 115 common carp *Crustaceae*, *Chironomidae* and *Oligochaetae* were far less important than in other ponds studied owing to the limited availability of these animals. However small fry of *Tilapia* and *Lebistes* was most frequently eaten by the carp and formed its major diet here.

In this extreme environment *Lebistes reticulatus*, feeding on *Rotatoria* and phytoplankton — a kind of food too small for the common carp — here does not act as a competitor for food as is the case in all other ponds studied, but in as important chain in the food-cycle of the carp.

6. As a general conclusion derived from the study of all ponds it might be stated that the common carp in Indonesian ponds proved to be an opportunistic, polyphagous feeder. Its diet is mainly dictated by local availability of natural food. Preferring *Crustaceae* from the open water and organisms among the shore vegetation and benthic organisms such as midge larvae and worms, it will turn to vegetable food and even show piscivorous habits when forced by absence of other food. Concerning the question of preference for *Crustaceae* or *Chironomidae* no conclusive answer can be given. The Bogor- and Sukabumi experiments indicate that, when *Crustaceae* are so abundant that without much effort the carp can ingest large quantities, not much other kinds of natural food will be eaten.

   Essentially we can support WUNDER's view for our ponds, that organisms from the open water are of equal importance as a source of food for the common carp as benthic organisms. Notably in the tropics the food cycle: phytoplankton — zooplankton — fish proceeds at a rapid rate. When feeding on a swarm of *Crustaceae* the common carp will be able to ingest a good deal of food by simple straining and thus fill its guts in an easier way than eating benthic organisms from the mud.
7. Food chains as found in the carp ponds at Bogor and in the sewage pond at Bodjong Loa were depicted in two schemes.

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Obituary

Anna Petronella Cornelia de Vos

Amsterdam 14 I 1893 - Loosdrecht 21 III 1958

Nel DE VOS, as she was known to her friends, died on March 21 1958, at Loosdrecht (Holland) rather unexpectedly after a sudden and obstinate disease.

She was born on January 14 1893 in Amsterdam, where she absolved the final examination of a secondary school for girls. Then she first qualified as a primary school teacher on February 21 1913, taking the diploma for needlework on March 20 1914. Though the final examination did not qualify her for a University degree, she was matriculated as a student of biology the University of Amsterdam in 1914, and managed to get the certificate for secondary schoolteaching in biology and geology on September 14 1918.

But because of her interest in hydrobiology, she was appointed, October 30 1918, an assistant at the „Rijksinstituut voor Biologisch Visserijonderzoek" at Den Helder, where Dr. H. C. REDEKE was director. When in 1923 she reached her 30th anniversary, she was considered qualified (after an official colloquium on January 19 1923) for admittance to the University examinations. She became a bachelor of science on October 24 1923. Later on she was too much occupied by her work to pass further examinations.

She devoted all her time to the study of hydrobiology, particularly of the Dutch fresh and brackish waters. The investigations were for a great part carried out on board the „Meerval", the well-known vessel for inland water research, in use since November 1917, expecially after it got a permanent berth in the Bleekersingel at Gouda.

In the period of economization of the thirties her post was discontinued and she was placed on half-pay. With enthusiasm she took to the working out of the many data which she had collected. She then lived in her well-known hospitable countryhouse on the side of the river Vecht at Vreeland, in the midst of the typical Dutch landscape she loved so much.

Professor Max WEBER, former Director of the Amsterdam Zoological Museum, asked her assistance in compiling his cardsystems. On January 1 1938, she was appointed at the said Museum an adjunct-assistant of the Director, Professor Dr. L. F. DE BEAUFORT. Gradually she rose in the professional scale. January 1 1946 she was appointed conservatrix of the Museum. She specialized in Ostracods, also studying aquatic insects, larvae, Copepods, Oligochaetous and Polychaetous worms.

Among other work, e.g. studying the Ostracods as guidefossils, she continued the study of the material collected on the „Meerval".

Nel was loved by everybody because of her matter-of-fact, resolute, but kind character. Like many people who seem little sentimental, she had a warm heart for everybody, especially for people who depended upon her for their work.

After REDEKE's death in 1945 she looked after the edition of his book „Hydrobiologie van Nederland", which appeared in 1948. She had hoped to finish the study of her fresh-water collections in the leisure time she expected after her retirement, but, alas, the fatal illness aggravated and took her away before that time.

Prof. Dr. H. ENGEL
Dr. J. H. STOCK

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G. Evelyn Hutchinson: A Treatise on Limnology vol. I: Geography, Physics and Chemistry. John Wiley & Sons Inc. N.Y. 1957 $ 19.50.

It is astonishing to see that in these times one author can write so extensive and so thoroughgoing a treatise. It is of such completeness and recentness — for it gives the newest facts — that our first impression is: how will it be possible for one single author to go on in the same way in the second volume with the biology of lakes!

In this first volume there are 17 chapters, in which are treated:
The Origin of Lake Basins, The Morphometry and Morphology of Lakes, The Properties of Water, The Hydrological Cycle and the Water Balance of Lakes, The Hydromechanics of Lakes, The Optical Properties of Lakes, The Thermal Properties of Lakes, The Inorganic Ions of Rain, Lakes and Rivers, Oxygen in Lake Waters, Carbon Dioxide and the Hydrogen-Ion Concentration of Lake Waters, Redox Potential and the Iron Cycle, The Phosphorous Cycle in Lakes, The Sulfur Cycle in Lake Waters, The Silica Cycle in Lake Waters, Minor Metallic Elements in Lake Waters, The Nitrogen Cycle in Lake Waters, Organic Matter in Lake Water.

When looking at this contents, we find that the author not only is very familiar with the publications of American authors, but also of European publications, and that he entirely has exhausted the matter. For a long period to come this work will be the leading treatise for our knowledge of lakes.

It is a remarkable account of the events that are characteristic of what is occuring in lakes. Not only the title claims that the book is dedicated to Geography, Physics and Chemistry but the subjects are actually treated in detail.

For the moment being Mr. Hutchison's book is unequaled as to the knowlegde of inland waters. While reading we realize that the author himself has seen a great deal of the lakes he treats. He has travelled all over America, Scandinavia, Northern Italy, South Africa and Tibet. In his preface the author says „The aim of this book is to give as complete an account as is possible of the events characteristically occuring in lakes. The author, by training a biologist, is by inclination a naturalist who has tried to examine the whole sequence of geological, physical, chemical and biological events that operate together in a lake basin and are dependent one on another." We must admit that he did attain his aim and that his work is as useful as possible to all scientists who are directly or indirectly concerned with lakes.

P. v. O.

Vol. XII 4

CONTENTS

R. W. BUTCHER: An Underscribed Species of *Dunaliella* From the Cambridge Collection of Algae 249

P. VAN OYE: Quelques Desmidiées dites Arctiques Alpines des marais du sud-ouest d'Uvira (Congo Belge) 251

D. J. GARROD: The Growth of *Tilapia esculenta* GRAHAM in Lake Victoria.. 268

G. DEFLANDRE & M. DEFLANDRE-RIGAUD: *Difflugia? marina* BAILEY, une espèce oubliée, synonyme de *Quadrulella symmetrica* (WALLICH), Rhizopode testacé d'eau douce 299

K. F. VAAS & A. VAAS-VAN OVEN: Studies on the Production and Utilization of Natural Food in Indonesian Carp Ponds 308

Personalia: Obituary Anna Petronella Cornelia de Vos 393

Bibliography 396

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